NATIONAL
ACADEMY OF SCIENCES

BIOGRAPHICAL MEMOIRS

VOL. VI.

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
1909

WASHINGTON, D. C.
PRESS OF JUDD & DETWEILER, INC.
1909

PREFACE.

In accordance with the rules of the National Academy of Sciences, it is the duty of the President, upon the death of any member, to select some one to prepare a biographical memoir of the deceased. Such memoirs have been collected in permanent form from time to time, for the use of the Academy and for distribution among the large libraries of this country and Europe.

The present is the sixth volume and contains eighteen memoirs, one of which (that of W. A. Rogers) is merely the second part of a memorial sketch published in the fifth volume, giving a statement of his astronomical work. Each biography is supplemented by a list of the more important scientific publications of the deceased and is accompanied by a likeness and facsimile of the signature of the deceased member. It should be stated that several of the memoirs here brought together for the first time have been published elsewhere.

With the close of this volume ninety-four of these biographies will have been published by the Academy.

Arnold Hague,
Home Secretary.

Washington, D. C., *September 25, 1909.*

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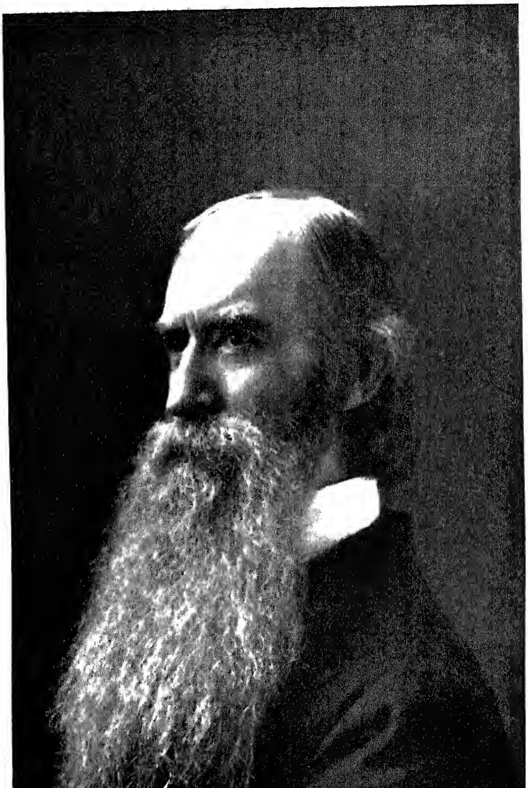

J. S. Newberry

BIOGRAPHICAL MEMOIR

OF

JOHN STRONG NEWBERRY.

1822–1892.

BY

CHARLES A. WHITE.

[READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL 17, 1902.]

BIOGRAPHICAL MEMOIR OF JOHN STRONG NEWBERRY.

It is more than ten years since our honored associate, Dr. JOHN S. NEWBERRY, died, but that event has not hitherto been commemorated in the archives of the Academy by the usual biographical memoir. Because of the great excellence of his character, and especially because it was long my privilege to call him my friend, I promptly undertook the task that has lately been assigned to me of preparing such a memoir, and I herewith present it to you.

JOHN STRONG NEWBERRY was born in the town of Windsor, Connecticut, on December 22, 1822, and died in the city of New Haven, Connecticut, on December 7, 1892, having then almost completed three score and ten years. He was a man of such prominence in scientific, educational, and national affairs and so much loved and respected by those who knew him, that many biographical sketches of him were published soon after his death. The facts pertaining to his life and labors have been so fully set forth in those sketches that, although I was personally cognizant of a considerable portion of his career, I prefer to use for the historical portion of this memoir much of the material that has been obtained from members of his family and other personal friends and embodied in the publications referred to. The following genealogical notes prepared by one of Dr. Newberry's sons have been extracted from one of those publications:

"Thomas Newberry, of Devonshire, England, settled in Dorchester, Massachusetts, about 1630. He died there about 1636, and his widow and children removed to Windsor, Connecticut, about the same year. His son, Captain Benjamin Newberry, was the first named of the seven proprietors to whom Windsor was patented in 1685. He commanded the military of the colony. He left two sons, Thomas, who was the ancestor of the Detroit and Chicago Newberrys, and Benjamin, who was our ancestor. Captain and Major Benjamin 2d seems to have succeeded to his father's position as chief of the military forces of the colony. His son, Captain Roger, married Elizabeth Wol-

cott, daughter of Roger Wolcott, governor of Connecticut. Captain Roger graduated at Yale College in 1726, and was a deputy to the general court for eleven sessions. In 1740 he commanded a company from Connecticut in the expedition against the Spanish Main, and was present at the repulse of Admiral Vernon at Cartagena in April, 1741. He died on the voyage home.

"General Roger Newberry, son of Captain Roger, received his commission as lieutenant in the colonial forces in 1767. He was commissioned as major in 1775, the commission being signed by Jonathan Trumbull, governor, and George Willys, secretary, of 'His Majesty's Colony of Connecticut.' In 1777 he received a commission as colonel, signed also by Jonathan Trumbull, governor, and George Willys, secretary, 'of the State of Connecticut.' In 1781 he was commissioned as brigadier general, and in 1783, after the peace, as judge of probate. He was one of the proprietors of the Connecticut Land Company, who purchased from the State of Connecticut the northern counties of Ohio, known as the 'Western Reserve.'

"Henry Newberry, son of General Roger, went to Ohio in 1824 to look after his father's landed interests. He located his land at the falls of the Cuyahoga river, and founded the town since known as Cuyahoga Falls. Upon this property was mined the first coal known to have been offered for sale in Ohio. My father, John Strong Newberry, was the younger of his two sons."

The lands of the Western Reserve Land Company were resold to settlers, a large part of whom were emigrants from Connecticut, of which State that region was then a recognized province. Many of those pioneer settlers were persons of education, who had enjoyed the advantages of a region that had already become one of the chief centers of education in America, and their intelligence and thrifty character were so strongly impressed upon the new communities that the results are to this day readily distinguishable among the inhabitants of that region, who are largely their descendants. It was in a community thus formed and characterized that the years of Dr. Newberry's childhood and youth were passed.

Although his father, Henry Newberry, with his wife and nine children, of whom John was the youngest and then only two years old, was among the earliest settlers, he made ample provision for the comfort and advantages of his family. Their

home was established at Cuyahoga Falls, about thirty-five miles south of the present city of Cleveland. Here the father became actively engaged in various enterprises, among which were his town proprietorship, the building of mills, and the opening and operating of coal mines. He also interested himself actively in securing an outlet for his products by way of Lake Erie, for railroads were then in their earliest experimental stage, and their future possibilities were not dreamed of by even the most sagacious business men. The son was thus reared in an energetic family and among men of strong, resolute, and intelligent purpose. These associations naturally gave strength to his own character, which was integrated and refined by the influence of a cultured home, presided over by a mother to whom her children gave loving obedience and to whom all others gave the sincerest reverence.

The physical surroundings of the boy were also fortunate and gave ample scope for the development of that love of nature by which he afterward became so strongly characterized. The fauna and flora of the region round about his home were then in their primeval condition and abundant in all their native forms. The valley sides of the Cuyahoga river presented many good sections of the underlying strata and betrayed the secret of their origin and that of the physical history of the valley. The shales taken from his father's coal mines were filled with fossil remains of plants of the by-gone Carboniferous age, not unfrequently accompanied with remains of fishes, and short journeys brought him in contact with other abundantly fossiliferous strata. The book of nature was thus opened at legible pages to his youthful eyes, and that he read it attentively and understandingly his after life abundantly proved. He early began to make collections, especially of living and fossil plants, and before he entered college he had made a large herbarium and prepared a "Catalogue of the Plants of Ohio." He had also filled a large room of his father's house with fossils to which in after years he gave long and effective study.

The early settlers of the Western Reserve gave their most earnest attention to the establishment of schools in the new communities, and young Newberry received instruction in the best of those which the region then afforded. When he reached the proper age he was prepared for college at a special school

that had been established in the town of Hudson, about eight miles from his home. Upon completing that preparation he entered Western Reserve College, which was also then established at Hudson, but it was some years afterward removed to Cleveland. He was graduated from that college in 1846, being then in his twenty-fourth year. During the last two years of his college course he also pursued studies in medicine, and upon his collegiate graduation he entered the Cleveland Medical School. He was graduated from the latter institution in 1848 with the degree of Doctor of Medicine.

At that time, in accordance with his previous intention, he began to formulate his plans for the practice of medicine as his lifework, but in doing so he met objections within himself. It is true that he had already received his medical degree and also much special instruction from the best of his medical teachers, but he was far from satisfied with his preparation for a profession which he had long held in the highest esteem. He therefore decided upon a course of foreign study, although he had already begun the practice of medicine at his home in Cuyahoga Falls. This determination he carried out in the autumn of 1849, and having a few months previously married Miss Sarah B. Gaylord, of Cleveland, he sailed with her for Paris, where they remained two years enjoying the advantages of that great center of science and art.

The young doctor was assiduous in his attendance upon medical lectures and clinics during his stay in Paris, greatly strengthening the foundation of his medical education and increasing his knowledge in various ways. The attractions of the museums, the Jardin des Plantes, and the scientific lectures of the distinguished men of that time were very great, and he profited by them to the uttermost, without detriment to his main purpose. He returned to America in 1851 and began the practice of medicine at Cleveland, where he met with immediate success. As time passed every thing seemed to indicate that he was permanently established as an eminent and much respected physician; but at the end of four years of the work for which he had so carefully prepared himself he came to the parting of the ways. Notwithstanding his sincere devotion to medicine, his love for the natural sciences was in no way diminished, but rather increased, as the years went on. Although his professional duties

were laborious, he continued his nature studies without interruption, and from time to time he published articles on those subjects which attracted much public attention.

During the years that Dr. Newberry was practicing medicine at Cleveland, the Government at Washington was preparing for the exploration of various portions of our great western domain. In 1855, an expedition was organized, under command of Lieutenant R. S. Williamson, to explore the country between San Francisco bay and the Columbia river, and Dr. Newberry was appointed assistant surgeon in the U. S. Army and geologist and botanist to the expedition. That was a position and an opportunity for which he had long been unconsciously preparing himself, and when the offer came he did not hesitate to close his medical practice at Cleveland and accept it. He chose the new way that was thus opened to him, and the results showed that he chose wisely. The Williamson exploring party made San Francisco the base of their field operations, and having accomplished the ordered explorations, they returned to Washington, D. C., arriving there in January, 1856.

While preparing the report of his field operations in Washington, he was chosen to the chair of chemistry and natural history in the institution at Washington known as the Columbian University,* but which is not to be confounded with Columbia University at New York city, with which he afterward became permanently connected. He retained his connection with the former institution for one college year, or only while he remained at the capital city.

In 1857 Dr. Newberry was appointed physician and naturalist to the Government expedition which was generally known as the Colorado Exploring Expedition, or the Ives Expedition, so-called from its commander, Lieutenant Joseph C. Ives. The thrilling experiences of the members of this expedition, especially in transporting their boats overland and ascending the Colorado river of the West as far as its great cañons, have become a part of the history of early explorations in the far western part of our country, most of which was then an unknown land. Dr. Newberry's labors as physician to the party and aid

* Since this article was written, this institution has changed its name to George Washington University.

to the commanding officer were very severe, but he nevertheless collected a large amount of information upon the geology and botany of the region which he traversed, and made many valuable notes upon the Moquis and other Indians of the Southwest. The party returned to Washington in the early summer of 1858, and Dr. Newberry spent the remaining months of that year in preparing his report.

In 1859 he was again in the field, this time as geologist of the San Juan Exploring Expedition, under the command of Captain J. N. Macomb, which began its work of exploration at Santa Fé in July of that year. This journey also took him over some of the wildest portions of our western domain and afforded opportunity for much valuable observation. He returned with the expedition to Santa Fé in the following November and went from there to Washington, where he remained until he had finished the preparation of his report. Owing to the then unsettled state of the nation, which culminated in the Civil War, that report was not published until 1876, seventeen years after the observations were made. Its publication after so long delay was in recognition of its great value; but because of that delay Dr. Newberry was deprived of the credit of priority, which was justly due him, in much of the important geological and ethnological work, which was afterward published by various authors from observations made in the region which he investigated when it was entirely new.

Upon the outbreak of the Civil War Dr. Newberry reported to the War Department at Washington, in whose service as assistant surgeon he had already passed five years. For the time and for that great emergency he was ready to abandon all his cherished plans for scientific work, and he promptly offered his country the benefit of his medical training and experience, which was as promptly accepted. He was appointed to the United States Sanitary Commission in June, 1861, and entered zealously upon his work. His ability and efficiency were at once recognized, and he was soon made secretary of the western department of the commission, which had supervision of the sanitary service in the great Mississippi Valley region, with headquarters at Louisville, Kentucky. He continued in this work of the sanitary service through and until after the close of the Civil War, and if he had never performed any other work

of any kind his service upon the Sanitary Commission would be sufficient to entitle his name to be held in grateful remembrance by his country and by humanity. One who was officially associated with him, and who was thoroughly acquainted with the workings of the commission, said of him: "All the agents of this work were selected by Dr. Newberry and assigned to their special duties. With an executive ability that is rarely equaled, he seemed instinctively to put every man to the task he was best fitted for and to keep him up to his most efficient work. All reported to him at least every month, and oftener when emergencies demanded. All were treated with the utmost kindness and consideration, and all learned to love and honor him. No part of his life-work is entitled to higher honor."

Should time permit I would like to dwell long upon this great work of Dr. Newberry, but I can only make passing reference to a summary of it, written by himself. It is represented by entry number 60 in the accompanying list of his published works and consists of 543 octavo pages. A crowning proof of his integrity of character is found in the full accounting which he rendered to the Government for all the money and property, amounting to millions of dollars, that passed through his hands in the course of his official work.

It was while Dr. Newberry was engaged in the great work of the U. S. Sanitary Commission that our Academy was organized, and he naturally became one of the original fifty members. His subsequent as well as his previous scientific work shows how well he deserved that honor.

At the close of the Civil War, in 1865, his inclination was strongly toward a resumption of his scientific pursuits rather than a return to the practice of medicine. The Smithsonian Institution then offered the best advantages available to him for research, and he accordingly became a scientific associate of that renowned institution. This association, however, was of short duration, for in the next year, 1866, he entered upon what was to be his chief life-work in science and education—that is, he was then chosen to the Chair of Geology and Paleontology, which was at that time established for the School of Mines of Columbia University, in New York city. He was the first occupant of that chair and he retained it until his death, twenty-six years afterward.

This settlement in educational and scientific work was the consummation of Dr. Newberry's earnest desire and the fulfillment of his early dreams. From this time on his career was free from radical changes, and was one of steady growth, immense labor, and abundant results. Important as were his previous scientific labors and great as was his work upon the U. S. Sanitary Commission, we must regard the years during which he occupied his chair at the School of Mines as the most important period of his life. It was within that period that he produced his greatest impression upon the university which honored him and which he honored, upon scientific education throughout the land, upon its rising young men, and upon the city which was the scene of his labors.

The impression which he produced upon the scientific world is largely indicated by his published works, much the greater part of which were written within that period. He was one of the chief agencies in bringing about the organization of the School of Mines for Columbia College, which was one of the more important steps that were then and afterward taken toward making the college a university in fact. He labored constantly and with great success to bring up that school to a high standard of efficiency. Its museum, which is one of the best of its kind, was his creation, and a large part of its fossils, rocks, and minerals are of his personal collection. His influence upon the citizenship and the municipal affairs of New York city was very great, and he was constantly consulted upon scientific and hygienic questions pertaining to the city government and policy. When he assumed the duties of his professorship general interest in New York city upon scientific matters was at the lowest ebb. Under his influence the moribund "Lyceum" was rehabilitated and soon became the living, flourishing New York Academy of Sciences of today, and other scientific institutions of the city shared in the general awakening that his influence created.

Of his influence upon his students at the School of Mines I will speak further on, and now refer briefly to his characteristics as an educator and to the honors which have been bestowed upon him. When he and his fellow-American naturalists were in the earlier years of their manhood and of their isolated studies there were no schools of science in America, and neither geology nor any of the biological sciences had a distinctly recognized place

in any college curriculum. The first teachers of these sciences were necessarily the self-taught naturalists of those days. Among those teachers Dr. Newberry began his educational work with the broadest preparation, of which his medical and surgical training was an important feature, and he was unquestionably one of the ablest teachers of his time. When he came to his chair at the School of Mines he was possessed of a matured originality of thought and constructive ability, which enabled him to organize his courses of instruction upon such an efficient plan that it has needed little change to this day. He came to his educational work, as he did to that of the Sanitary Commission, with an effective grasp of the subject, which was that of a veteran.

All the honors that were naturally due to one of his ability came to him as a matter of course, among which the following may be mentioned: He was President of the American Association for the Advancement of Science for the meeting at Burlington, Vermont, in 1867, and in the same year his Alma Mater conferred upon him the degree of Doctor of Laws. In 1868 he was elected president of the Lyceum of Natural History of the City of New York (which in 1876 became the New York Academy of Sciences), and he remained its president by annual reëlection until his death, twenty-four years afterward.

For some years after his college work was established at New York, Dr. Newberry retained his residence and citizenship at Cleveland, and when, in 1869, the Geological Survey of Ohio was provided for by legislative enactment he was chosen to be its director. For three years thereafter he gave that work all the time he could spare from his college duties, but after those three years he gave it less attention, although he continued to publish reports of the survey. In 1874 the work of the survey was suspended by failure of the legislature to provide the necessary funds, and much dissatisfaction, and even bitterness of feeling, was engendered among those who had taken part or had been interested in it. Dr. Newberry thought, and with apparently good reason, that injustice had been done him in his relation to the survey. Soon after its suspension he removed his residence from Cleveland, Ohio, to New Haven, Connecticut, where he ended his days.

At the Centennial Exposition, which was held at Philadelphia in 1876, he was appointed one of the judges, and made a

report on the building and ornamental stones. In 1880 he was elected President of the Torrey Botanical Club, in New York city, which office he held by annual reëlection for ten consecutive years. In 1884 the United States Geological Survey assigned to him the investigation of its fossil fishes and a part of its fossil plants. In 1888 he was awarded the Murchison Medal by the Geological Society of London for distinguished services to geological science. He became an original member of the Geological Society of America in 1888, and was elected first vice-president of the society for the following year. He was one of the organizers of the International Congress of Geologists, and was elected its President for the meeting at Washington in 1891; but his failing health made it impossible for him to perform the duties of that high position or even to attend any of the meetings of the Congress. Besides the aforementioned honors that came so justly to our distinguished associate, he held honorary membership in most of the learned societies of America and a large part of those of Europe.

In the autumn of 1889 Dr. Newberry showed signs of exhaustion, which was due to his advancing years and severe labors, and in the following winter he took a severe cold, from the effects of which he never fully recovered, although he still continued to work. Even during his summer vacation in 1890 he continued to work upon the "Fossil Flora of the Amboy Clays," which task he greatly desired to bring to a close. But the beginning of his end was near, for on December 3, 1890, he was prostrated by a stroke of paralysis. He rallied a little soon afterward, and for a part of the year 1891 he attended to his duties at the college during a few hours each day, but his need of absolute cessation from work was imperative. He sought recuperation in the Southern States, in California, and on the shores of the Great Lakes, but to no purpose, and with waning strength he returned to his home in New Haven in 1892. On December 7 of that year the end came and the good man was at rest.

To my mind it is unnecessary and inappropriate for one who has been chosen to write for our archives a biographical memoir of a deceased associate to criticise in judicial terms either the intrinsic or relative value of his published works. If I should attempt it in Dr. Newberry's case I am sure I should be quite as likely to err upon any point as he may have been. I herewith

append a bibliographical list of his published writings, consisting of two hundred and twelve entries and extending over a period of full forty years. These publications are before the world for its deliberate judgment, and I have no fear that the result will be unfavorable. They comprise a remarkable range of subjects for the labor of one man, the chief of which are geology, both general and economic; paleontology, both vegetable and animal; physiography, zoölogy, botany, and archæology.

My more than thirty years' acquaintance with Dr. Newberry was to me a constant source of pleasure and intellectual profit. He seemed to have high ideals in mind for discussion whenever we met; but still he was eminently human, and I loved him because he was so. His individuality was so distinctive and his personal and professional influence upon other men so great and beneficial that I would like to present to you an adequate estimate of them, but I can at best only make a few brief and disconnected references to them on this occasion. He was possessed in a marked degree of the four cardinal virtues of the ancient philosophers—justice, prudence, temperance, and fortitude—and to these were added charity and human kindness in the fullest measure. He was prompt to render and to require justice. If he ever erred in prudence, it was toward charity. His temperance was that of the highest type of manhood, and the greatness of his fortitude was eminently shown in the protracted closing scene of his life.

The full extent to which he exercised the virtue of human kindness can never be fully known, because it was always unobtrusively done; but it is known that he extended it even to the lowermost limits of humanity. General William Birney, who was his fellow-sojourner in Paris and his life-long friend, reminiscently gives me that testimony of him. He says, for example, that he never knew Dr. Newberry to pass a beggar in the streets of that city without bestowing alms. That was an approved form of charity and of modest recognition of "noblesse oblige" in those days, and he continued the habit in after life, often against his better judgment, evidently because it grieved him to witness even seeming distress without trying to relieve it. His old friend mentions other instances illustrating his inborn kindliness, but the foregoing are sufficient to show the great breadth of his humanity.

A marked feature of his individuality was his sincerity. He was always free in conversation, but never trivial. He was kindly and genial, but there was always a serious earnestness in his manner that reflected his sense of right and of the responsibilities of life and its labors. He did his scientific work and spoke of it with a sincerity that indicated a high estimate of every fact connected with it. He was never irreverent, but a physical fact was to him as sacred as a moral principle or a religious tenet.

Few men have worked in so many different fields or worked so well in them as Dr. Newberry. He was a naturalist in the broadest sense of the word, and a great one. Many of the best American naturalists who were his contemporaries achieved their successes in the face of obstacles and disadvantages that would have dismayed most men. He had advantages superior to theirs, and having the same indomitable energy he was to that extent their superior in the accomplishment of results. Yet nothing was further from his thoughts than an undue assumption of superiority over any of his colaborers in science. He was always ready, in a natural and friendly manner, to give encouragement and approval to any friendly naturalist who was capable of profiting by it, and the recipient of favors of which he was the real author often did not know whence they came. He enjoyed the proper and discreet use of his own influence in favor of a deserving friend.

Perhaps no teacher ever commanded more sincere and loving respect from his students than was accorded to Dr. Newberry by the classes of young men who from year to year thronged his lecture-room at the School of Mines. He was literally their "guide, philosopher, and friend." All of them, as they have gone out into the world, have taken important part in its activities, many have themselves become teachers, and all revere his memory. I think it not too much to say that the influence which he exerted upon these men by his personal contact with them and the instruction which he imparted during the twenty-six years of his professorship was as great and beneficial as that which has been exerted by his published writings, valuable and numerous as the latter are.

It was sad to see our friend stricken down while he was yet in the full vigor of his intellectual faculties and in the full exer-

cise of his influence for good, but his fortitude in the face of impending death excited our admiration. We felt that he had accomplished the full measure of a life's work, that the world is better and wiser for his having lived in it, and that to us his life had been a benison.

LIST OF PUBLICATIONS OF PROFESSOR JOHN S. NEWBERRY.

1. Description of the Quarries Yielding Fossil Fishes, Monte Bolca, Italy. Family Visitor, 1851.
2. On the Currents of the Gulf Stream and of the Pacific off Central America. Family Visitor, 1851.
3. On the Geographical Distribution of Certain Species of Land and Fresh Water Shells. Proc. Amer. Asso. (1851), p. 105.
4. On the Origin of the Quartz Pebbles of the Carboniferous Conglomerate. Family Visitor, 1851.
5. On the Specific Identity of Typhus and Typhoid Fevers. Minutes Ohio State Medical Society, 1852.
6. On the Fossil Fishes of the Cliff Limestone. Annals of Science (1853), p. 12.
7. On the Structure and Affinities of Certain Fossil Plants of the Carboniferous Age. Proc. Amer. Asso. (1853), p. 157; Annals of Science, vol. I, p. 268.
8. On the Carboniferous Flora of Ohio. Proc. Amer. Asso. (1853), p. 163; Annals of Science, vol. I, p. 280.
9. Catalogue of the Fossil Plants of Ohio. Annals of Science (1853), vol. I, pp. 95 and 106.
10. New Fossil Plants from Ohio. Annals of Science (1853), pp. 116, 128, and 153.
11. Fossil Plants from the Ohio Coal Basin. Annals of Science, vol. I (Cleveland, 1853), pp. 2–3, 95–97, 106–108, 164–165, 268–270.
12. New Genera and Species of Fossil Fishes from the Carboniferous Strata of Ohio. Proc. Phil. Acad. Sci. (1856), p. 96.
13. Report on the Economic Geology of the Route of the Ashtabula and New Lisbon Railroad. Cleveland, Ohio (1857), 8vo, pp. 49.
14. On the Mode of Formation of Cannel Coal. Amer. Jour. Sci., vol. XXIII (1857), p. 212.
15. Geology of California and Oregon. United States Pacific Railroad Report, vol. VI (1857), pp. 1–73, pl. V.
16. The Botany of Northern California and Oregon. United States Pacific Railroad Report, vol. VI (1857); Botanical Report, pp. 1–94, pls. I–XVI.
17. Zoölogy of Northern California and Oregon. United States Pacific Railroad Report, vol. VI (1857), pp. 37–100, pls. I–V.

18. Fossil Fishes of the Devonian Rocks of Ohio. Bulletin National Institute, January, 1857.
19. Reports of the Geology, Botany, and Zoölogy of California and Oregon. Reprint from P. R. R. Report, vol. VI, 4to, pp. 250, pl. XXXIX.
20. Catalogue of Plants of Ohio. Ohio Agric. Report (1859), and Reprint, pp. 41.
21. The Rock Oils of Ohio. Ohio Agric. Report (1859), and Reprint, pp. 16.
22. Explorations in New Mexico. Amer. Jour. Sci., vol. XXVIII (1859), p. 298.
23. Fossil Plants from the Cretaceous of Kansas and Nebraska (from a letter to Meek and Hayden). Amer. Jour. Sci., part II, vol. XXVII (1859), pp. 31–35.
24. Cretaceous and Tertiary Plants. Hayden's Report on Exploration of Missouri and Yellowstone Rivers, Washington (1859–1860), p. 146.
25. The Ancient Vegetation of North America. Amer. Jour. Sci., vol. XXIX (1860), p. 208.
26. The State-House Well of Columbus, Ohio. Report of Superintendent of State House (1860), and Reprint.
27. The Aurora of 1859. Amer. Jour. Sci. vol. XXX (1860), pp. 347–356.
28. The American Cretaceous Flora. Amer. Jour. Sci., vol. XXX (1860), p. 273.
29. Geology of the Colorado Exploring Expedition. Washington (1861), 4to, pp. 153, pl. 6, 2 maps.
30. The Ancient Vegetation of North America. Canadian Naturalist and Geologist, vol. VI (Montreal, 1861), pp. 73–80.
31. The Surface Geology of the Basin of the Great Lakes. Proc. Boston Nat. Hist. Soc., vol. IX (1862), and Reprint, pp. 7.
32. Notes on American Fossil Fishes. Amer. Jour. Sci., vol. XXXIV (1862), pp. 73.
33. Description of Fossil Plants collected by the Northwest Boundary Commission. Proc. Boston Nat. Hist. Soc., vol. VII (1863), and Reprint, p. 19.
34. The Oil Region of the Upper Cumberland in Kentucky and Tennessee. Cincinnati, 1866, pp. 10.
35. Prospectus of Neff Petroleum Company, Knox County, Ohio (1866), pp. 16–23, 40–43. Gambier, Ohio.
36. Report on the Fossil Fishes collected on the Illinois Geological Survey, by J. S. Newberry and A. H. Worthen. Rept. Geol. Survey of Illinois, vol. II (1866), pp. 1–134, pl. XIII.
37. On the Age of the Coal Formation of China. Amer. Jour. Sci., part II, vol. XLII (1866), pp, 151–154.
38. Modern Scientific Investigation, its Methods and Tendencies. Presidential Address, Proc. Amer. Asso. (1867), p. 1, Reprint.
39. Report on the Fossil Plants collected in China by Mr. Raphael Pumpelly. Smithsonian Contributions (1868), p. 119, pl. 1.

40. Sketch of the Geology of Ohio. Walling's Atlas of Ohio (1868), with geological map.
41. Geological Survey of Ohio. Report of Progress for 1869, part I, pp. 1–52, map and chart.
42. Fossil Fishes of Illinois, Newberry and Worthen. Geol. Survey of Illinois, vol. IV (1870), p. 343.
43. Notes on the Later Extinct Floras of North America. Annals Lyc. Nat. Hist., vol. IX (1870), p. 1, Reprint, 8vo, pp. 76.
44. On the Surface Geology of the Basin of the Great Lakes and the Valley of the Mississippi. Annals Lyc. Nat. Hist., vol. IX (1870). p. 213. (See also Amer. Jour. Sci., vol. XLIX (1870), pp. 111 and 267.)
45. The Geological Survey of Ohio. Address delivered to the legislature, February 7, 1870, pp. 60.
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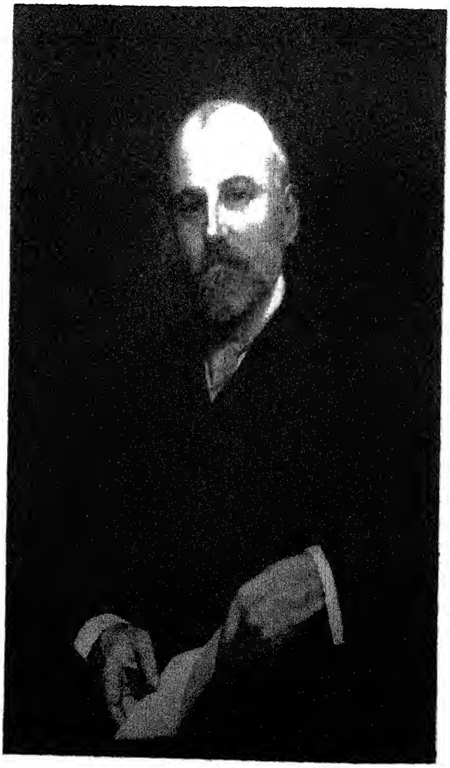
Some of Dr. Newberry's cyclopedic writings are mentioned in the foregoing list, but his chief work of that kind was done for Johnson's Cyclopedia. He was one of the editors of that work, having had special charge of the subjects pertaining to geology and palæontology. Besides the elaborate articles on these subjects from his own pen which that cyclopedia contains, he aided his editorial associates with reference to a multitude of other relevant subjects. This mass of cyclopedic work, therefore, should receive distinct recognition in any bibliographical list of his writings.



Clarence King

BIOGRAPHICAL MEMOIR

OF

CLARENCE KING.

1842-1901.

BY

SAMUEL FRANKLIN EMMONS.

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL 23, 1903.

BIOGRAPHICAL MEMOIR OF CLARENCE KING.

The greatest advance in geological science in the past half century has been due less to the brilliant generalizations of individual investigators, of which, however, there has been no want, than to the systematic organization of geological work which has given a sounder basis for theoretical deduction and rendered the work of the individual more permanent and effective.

It was not until the truth that geological studies could not be profitably confined within State lines or other artificial boundaries had been proved by practical demonstration that the aid of the general government was freely and permanently enlisted and thereby geological science in America raised to its present high position.

To the accomplishment of this result the late CLARENCE KING was the foremost and one of the most active contributors. His influence on the development of geological science in this country was exercised at a critical point in its history, when the personality of the man, aside from his purely scientific ability, played a much greater part than it would at the present day, when the labors of men of his type have already borne abundant fruit in impressing upon the people at large the practical importance of a scientific guidance in the development of their material resources. It seems, therefore, appropriate in speaking of the man, even to a strictly scientific audience like the present, that the more personal element should receive attention.

For believers in atavism a consideration of King's ancestry will possess a peculiar interest. On both sides he came of good English stock planted on New England soil, where conditions seemed propitious for the gradual development of the varied characteristics that showed themselves so remarkably combined in this brilliant man.

Daniel King, the first of the name in this country, came to Lynn, Massachusetts, in 1637—a younger son of Ralphe Kinge of Watford, in Hertfordshire, England.

Fifty years later we find his son, Capt. Daniel King, a resident merchant of St. Kitts, in the West Indies. On the floor of St. George's chapel at Basseterre, on that island, is a stone bearing the arms of the King family and recording the death of Benjamin King, presumably Daniel's son.

Benjamin King, a grandson of the first Daniel, moved from Salem to Newport in the first half of the eighteenth century, dying there in 1786. In him already was Commerce giving way in a measure to Science, for he displayed strong tastes in the latter pursuit, which the means acquired in the former permitted him to indulge, and he made a point of importing from Europe the latest philosophical instruments. It is a family tradition that the great Benjamin Franklin, on one of his voyages between Philadelphia and Boston, visited him to view the latest electric novelty—a Leyden jar.

Next Art came to pay her tribute, for Samuel, son of Benjamin the scientist, was a portrait painter of no mean repute, and numbered among his pupils the famous Washington Allston and Malbone, the miniaturist.

The maternal side contributed literary culture and statesmanship.

The Honorable Ashur Robbins, one of King's great-grandfathers, was born at Weathersfield, Connecticut, in 1761, and died at Newport, in 1845. He graduated at Yale in 1782, married Mary Ellery in 1791, was United States district attorney at Newport in 1812, received the honorary degree of LL.D. from Brown in 1835, and from 1825 to 1839 served his country with distinction in the United States Senate. He was distinguished as an orator and classical scholar and was a friend and associate of Daniel Webster.

William Little, another great-grandfather, was a graduate of Yale in the class of 1777 and received an honorary degree from Harvard in 1786. His son, William Little, Jr., was already distinguished as a linguist and classical scholar, when he died at the early age of 40. His wife, Mrs. Sophia Little, Clarence's grandmother, from whom he evidently inherited many characteristic traits, was a poetess and philanthropist, a woman of remarkable public spirit, energy, and decision of character. She retained her mental and physical vigor in the most remarkable degree up

to the time of her death, at the age of 95, in 1893. Her son, Robbins Little, was for many years librarian of the Astor Library, New York.

The immediate ancestors of the name were pioneer merchants of the East India and China trade in the first half of the last century. His grandfather, Samuel Vernon King, moved from Newport to New York, and in 1803 was senior partner in the commercial house of King & Talbot. His four sons, Charles, James, Frederick, and David, successively replaced him in the firm, which became known as Talbot, Olyphant & Company, and later as King & Company. Three of these four brothers died in the far East; the fourth fell in the first year of the Civil War.

James, the father of Clarence, though induced by family influence to follow the calling of a merchant, had a natural leaning toward scientific studies. He married Florence Little at the age of 21, but was obliged to leave his young wife before the birth of their first child in order to take the place of his elder brother in the house in China. He died suddenly at Amoy, China, in 1848, leaving as a legacy to his wife and only child his interest in the business of the China firm.

The young mother, left a widow at 22, devoted herself to the education of her son, learning with an inherited facility both classical and modern languages that she might teach them in turn to him, and cultivating the taste for natural science, an inherited quality, which early showed itself in the child. While living at Pomfret, Connecticut, whither she had gone that he might have the benefit of Dr. Park's excellent school for boys, the young Clarence, then only seven years old, came to his mother one day in January, when the ground was covered with frozen snow, and asked if she could go a little way with him to see something. The little way proved to be about a mile and the something a remarkably distinct fossil fern in a stone wall, and the boy wished his mother to explain to him how it came there. Books on geology were consulted, and from that time on, she writes, "my rooms became a veritable museum, where all kinds of specimens were studied with enthusiasm." In his later school-boy days, which were principally spent in the endowed high school at Hartford, Connecticut, while in the summer vacation trips in the Green Mountains were devoted to camping out among

the rocks and plants he loved to study, his mother was his companion and guide. As the boy developed into the man and as the relative disparity of age lessened, there grew up between them a close intellectual companionship that never weakened during his lifetime. She was a woman of remarkable intellectual caliber, who might readily have made a name in literature had she had that ambition; but she was contented to live in the reflected glory of her son's reputation. On his side, his tender affection and solicitude for her welfare was one of the most marked traits of his character, and through all the many vicissitudes of his checkered life his first thought and duty was to provide for her comfort and happiness.

In the crisis of 1857 the house of King & Company became bankrupt through the loss of a steamer which, in charge of a confidential clerk, was carrying a large amount of specie to meet their liabilities at another port, and the property which had been left by James King for the support of his widow and only son was thereby lost.

Not long afterward King entered as a clerk in a business house with the idea of following a commercial career, but although he succeeded in satisfying his employer, his natural taste lay so strongly in the direction of science and literature that he could not satisfy himself, and after a few months' trial abandoned the attempt.

In 1859 he became a student at the Scientific School at Yale, then a much less prosperous and generously endowed institution than at the present day, but rich in the possession of such inspiring teachers as James D. Dana and George J. Brush. Already, according to the testimony of his fellow-students, King showed many of the qualities which distinguished him above his fellows in later life. He studied enthusiastically both in books and in nature. His observations of natural objects, plants, animals, or rocks were so vivid that they seemed to photograph themselves upon his memory, so that he could recall the picture at will. He wrote readily and with delicate literary judgment and skill, thanks to the influence of his mother's teaching. His love of outdoor life had so developed a naturally robust physique that he readily excelled in all athletic sports, especially rowing.

In whatever he was engaged, whether study or recreation, he was naturally accepted as a leader by his fellows.

In 1862 he was graduated from Yale College with the degree of B. S., his class being the first to which this degree was accorded by the University. During his college life his strong natural taste for scientific and artistic study of the greater features of natural scenery had been stimulated by reading the then popular works of Tyndall and Ruskin on the Alps of Europe, and Winthrop's stirring pictures of Northwestern America; and an even more direct impulse was given by the incidental hearing, in a letter to Professor Brush, of an account of the ascent by the members of the Geological Survey of California of Mt. Shasta, then supposed to be the highest peak in North America.

Immediately upon graduation he planned a boat trip from Lake Champlain down the St. Lawrence River to Quebec, which was carried out in company with his friends, James T. Gardiner, Samuel Parsons, Jr., and Daniel Dewey, in the autumn of 1862. They rowed themselves in a four-oared boat from Whitehall, on Lake Champlain, to Quebec, camping out *en route* and supporting themselves largely by the fruit of their rods and guns.

During the winter of 1862-'3 King was for a time a student of glacial geology under the elder Agassiz, and an enthusiastic member of an art club which, under the guidance of Russell Sturgis, devoted itself to the study of Ruskin and the pre-Raphaelite school of art.

The final impulse to the step which had the most influence upon his life was characteristically given by his solicitude for the welfare of another; his life-long friend Gardiner, having broken down in health through overstudy and an open-air life having been recommended to him, King planned a trip across the continent to the sunny skies of California. In May, 1863, the two young men proceeded to St. Joseph, Missouri, then the westernmost terminus of railroads and the starting point for emigrant travel across the plains. On the train between Hannibal and St. Joe King's kindly attention to the young children of a well-to-do emigrant family led to the adoption of Gardiner and himself as members of their party. The route followed by the party led up the valley of the North Platte River into

Wyoming, and thence by the South Pass and the Sweetwater Mountains across Green River Valley and around the northern end of Salt Lake to the Humboldt River, in Nevada, corresponding thus in a general way to that followed in later years by the transcontinental railroads and included in the belt which the party under King's charge was destined to survey.

The progress of the wagons was necessarily slow and about three months were occupied in the journey, which gave the young travelers, who were mounted upon their own horses, abundant opportunity for making detours along the route, of which they fully availed themselves. In more than one instance, while exploring the neighboring mountains, they ran the risk of capture by hostile Indians, but the experience thus gained was undoubtedly of great service in King's explorations of later years.

After crossing the deserts of Nevada they left the party and made a detour to the south to examine the already famous Comstock Lode at Virginia City. The very night of their arrival their lodging-house took fire and burned so rapidly that they barely escaped with their lives, losing everything they had with them, even to their letters and clothing. This was a serious blow, as they were entirely unknown in the place; but they were equal to the occasion, and having been fitted out by hospitable miners with rough clothing, they found employment in one of the quartz mills, where they worked until they had saved money enough to continue their journey. Starting anew, they crossed the Sierra Nevada on foot and reached Sacramento with just enough money to pay their passage on the river steamer to San Francisco.

On this trip they met by chance Prof. William M. Brewer, then first assistant of Prof. J. D. Whitney, of the Geological Survey of California, who was making a reconnaissance along the upper portions of the Sierra Nevada and had temporarily left his party in order to get further aid before going into the northern country, where the Indians were reported to be troublesome. The immediate result of this incident, his appointment as volunteer assistant geologist of the recently organized Geological Survey of California, was one that had a far-reaching effect on King's future career.

Although a few enterprising geologists had succeeded in pene-

trating the great mountain regions of the far west and had brought back vivid accounts of the phenomena observed at various points, the great region beyond the Mississippi River was still geologically a *terra incognita*, when in 1861 the legislature of California had appropriated a generous sum for a geological survey of that State and made Prof. J. D. Whitney its director.

No more attractive field for geological exploration and study could be found than that of the great Sierra Nevada, from which had already come a stream of gold whose volume had disturbed the monetary systems of the world. The problems presented in its structure were in many respects new in the experience of the American geologist, especially in the field of vulcanism, whose manifestations in the eastern part of the continent, where students of geology had hitherto been mainly occupied, are comparatively insignificant. To King, full as he was of youthful energy and enthusiasm, the prospect of exploring the summits of this great range and repeating in the Alps of America the experiences of Tyndall and Ruskin in those of Europe was indeed a powerful inducement for joining the Survey, and how abundantly and fruitfully he embraced the opportunities is well shown in his delightful book on "Mountaineering in the Sierra Nevada."

His first experience was as an assistant to Professor Brewer, when, in September, 1863, they explored the regions in northern California, where the granite crest of the Sierra Nevada suddenly breaks down and is succeeded by broken hills and lava-capped plains out of which rise the imposing volcanic cones of Lassens Peak and Mt. Shasta. Here he had his first opportunity for a field study of volcanic rocks—a study in which, aided by the teaching of his great friend, the German geologist Von Richthofen, he afterward became so proficient that for many years he was recognized as the highest American authority upon the subject.

A large portion of the summer of 1864 was spent in exploring the southern part of the Sierra Nevada around the Yosemite Valley and the high peaks to the eastward at the headwaters of the King and Kern rivers. In climbing one of the highest peaks of this group, which they had called Mt. Tyndall, two still higher ones were discovered, to the loftier of which, evidently the cul-

minating point of the whole Sierra, they gave the name of "Mt. Whitney" in honor of their respected chief. This King attempted to climb later in the same season, but when near the summit he found his further progress stopped by a sheer wall of granite which rendered its ascent from that side impossible. To show the great unwillingness of the man to abandon any important enterprise that he had undertaken, it may be stated that long after he had severed his connection with the California Survey he twice repeated the attempt from the other side of the range. In 1871 he supposed he had attained the highest point, but a storm coming up just as he had reached it, the clouds in which he was enveloped hid the true summit, which was a little higher than the one which he was on. Two years later the news came to him in New York that observations by a member of the California Survey had proved his error, and without a moment's delay he crossed the continent and climbed it again, this time reaching the actual summit, the highest peak within the United States.

In the summer of 1868, with William Ashburner, the distinguished mining engineer, he was for a time engaged in an economic survey of the Mariposa land grant under F. L. Olmsted, and it was during the progress of this work that he made the discovery of the fossil that finally settled the question of the age of the auriferous slates of the Sierra Nevada. In the following winter, the Survey funds being exhausted through lack of appropriations, he with his friend Gardiner returned to the east by the Nicaragua route, spending two weeks on the Isthmus while waiting for a steamer to New York. On his arrival he was detained for a long time at the house of his stepfather, George S. Howland, at Irvington-on-the-Hudson, by an attack of malaria, after which he took a post-graduate course in field and practical astronomy at Yale.

Returning again to California in the autumn of 1865, the two young men were soon after their arrival engaged as geological and topographical engineers for an exploratory expedition through Arizona, made by General McDowell with a company of cavalry. This expedition occupied the winter of 1865-'6 and, carried on as it was in a desert country infested by hostile Apaches, involved no little hardship and danger. At one time,

while carrying on their scientific work out of sight of their escort, they were ambushed by a party of Indians and only escaped death through the coolness of King, who first prevented his companion from making what he perceived to be a futile resistance, and later delayed the preparation of their torture by fire by exciting the curiosity of the Indians by his barometer, which he explained was a new kind of long-distance gun, and thus gained time enough to allow the cavalry to come in sight and effect their rescue.

In the spring of 1866, further work in Arizona having been rendered impracticable by the substitution of raw infantry from the east for the California cavalry, which had hitherto been an efficient guard against the Apaches, the young men returned to San Francisco, making the difficult and then somewhat dangerous journey across the great deserts of southern California alone, being obliged to travel at night and lie by during the daytime that they might not be seen by the Indians and also to avoid the great heat of midday sun. After working up the results of their field work they resumed their connection with the California Survey and spent the following summer in surveying the high Sierras to the east of the Yosemite Valley. It was during this work, according to Mr. Gardiner, that they planned the system of rapid surveying by triangulation checked by astronomical locations and barometrical measurements which was later so successfully carried into practice in the Exploration of the 40th Parallel.

In the early autumn, while still engaged in this work, King received news of the sudden death of his stepfather, Mr. Howland, and at once started home to be near his mother, who, with three young children left dependent upon her, for the second time found herself reduced from affluence to comparative poverty.

At this crisis he found himself in a position whose difficulties would have daunted a less courageous and sanguine nature. Without other means than his active brain and the experience gathered during his four years' apprenticeship on the California Survey, he had not only to make a career for himself, but to provide for the comfort of those who naturally looked to him for protection and support. That experience, however, was one that was invaluable to him at this time. He had familiarized himself

with the best method of overcoming the natural difficulties to be met with in carrying on scientific exploration in the west, and thus so strengthened the inborn self-reliance of his nature that, as in the case of reaching the summit of Mt. Whitney, failure seemed only to spur him on to further effort.

Not long after his return to the east, therefore, he determined upon attempting to carry out the project that had been gradually shaping itself in his mind ever since he first crossed the continent, that, namely, of inducing Congress to authorize the making of a geological and topographical survey across the entire Cordilleran system at its widest point, and thus connecting the geology of the east with that of the west. Before leaving California he had submitted his plan to Professor Whitney, but the latter, while thoroughly appreciating its great scientific importance, had refused him any written indorsement for the reason that he believed the natural obstacles in its way to be insurmountable.

King, however, confident of the feasibility of his plan, felt that then, if ever, was the time to favorably influence the minds of our statesmen, when their best endeavors were directed to strengthening the liens that bound the various parts of our great country together. There had been considerable apprehension during the dark days of the Civil War lest California, physically isolated as she was at that time, should separate from the other States and set up an independent government. The subsidizing of the transcontinental railroad was the first step toward overcoming this isolation and binding her more closely to the east; but still another step was necessary; the resources of the intermediate region should be ascertained and a foundation laid for the development of the mineral wealth locked up in its mountains and desert plains, the importance of which few beside himself were able at that time to appreciate. In no other way could this be more thoroughly accomplished than by such a scientific exploration as he proposed. Subsequent events have abundantly proved the correctness of this view, for nowhere in the history of the world has there been recorded such an amazingly rapid and permanent development of a comparatively unknown region as has been effected in the thirty years that have elapsed since the opening of the transcontinental railroad.

It was with the object of impressing this view upon Congress and influencing their favorable action that in the winter of 1866-'7 King, then barely 25 years old and looking still more youthful, presented himself at Washington armed only with a few letters of introduction from his college professors and from friends whom he had made in California. It was to his earnestness and the magnetic influence of his personality rather than to these letters, however, that was due the favorable impression he soon made upon the leading men to whom he first addressed himself. Chief among these were John Conness, of California, and Abram S. Hewitt, of New York, who became his legislative advisers and champions upon the floors of the Senate and the House respectively; General A. A. Humphreys, Chief of Engineers, eminent not only as a military commander, but also as a scientist, under whose administrative control the survey was carried on, and Spencer F. Baird, Secretary of the Smithsonian Institution, his scientific adviser, all of whom soon became and always remained his warm and sympathetic friends.

On the second of March, 1867, Congress approved a bill whose last clause authorized the Secretary of War "to direct a geological and topographical exploration of the territory between the Rocky Mountains and the Sierra Nevada Mountains, including the route or routes of the Pacific Railroad." No definite sum was appropriated at that time, as the bill provided that the expense should be met out of existing appropriations, but it had been arranged beforehand that certain unexpended balances of appropriations for surveys for a military wagon road across the continent should be used for this purpose.

Five days later King received his formal appointment as Geologist in Charge of the Geological Exploration of the 40th Parallel, and at once proceeded to organize his corps. As all the resources of the country were to be studied, animal and vegetable as well as mineral, this included, besides geologists and topographers, also a zoölogist and a botanist; a feature novel at that time was the addition of a photographer, to which position a man was selected who had had wide field experience with the Army of the Potomac during the Civil War. An escort of cavalry was also provided as a guard against possible danger from hostile

Indians, which proved a by no means useless though sometimes troublesome adjunct.

In the following May the party proceeded to California by way of the Isthmus of Panama, but it was near the end of July before all the necessary preparations had been made and they took up their march from Sacramento across the Sierra Nevada to their field of work.

In these days, when the West is covered by a network of railways, it is difficult to conceive of the obstacles that had to be overcome in carrying out so ambitious a work as that which King had planned. Of the transcontinental railroads but a few miles at either end had yet been constructed. The territories of Utah and Nevada were represented on most maps of the day as one broad desert, and it was considered doubtful whether sufficient water and grass could be found there to support a camping party.

Through such a country it was designed to carry, not a simple meander survey along a previously chosen route, as had hitherto been the custom in military explorations, but the detailed mapping, both topographical and geological, of an area about 100 miles in width, which finally extended nearly 1,000 miles in length.

As far as was possible to human foresight, King had provided means to overcome the difficulties liable to be encountered. Guided by his previous experience in such work, he had personally supervised the preparation of every article of the party's equipment, from the scientific instruments, many of which were specially constructed for the purpose on his own special designs, down to the minor details of construction of wagons and pack saddles. Nevertheless there were many times, especially in the first two seasons' campaigning in the deserts of Nevada, when, through weakness resulting from malarial fever contracted in the Sacramento Valley bottoms, the impossibility of obtaining potable water, a shortness of food supplies, or delays from storms or other causes, discouragement took possession of different members of the party. But King's abundant courage and energy never failed and his fertility in expedients was equal to every emergency; so that he gradually impressed upon every member of his corps such confidence in his ability as a leader

that their personal devotion to him and their faith in the complete success of the undertaking knew no bounds.

In 1869, when the two ends of the transcontinental railroad had met in the Salt Lake Valley, the work of the Survey had been carried eastward to the boundary of Wyoming, which was the eastern limit of the area it was primarily intended to survey. In recognition of the public demand for a direct application of the results of government geological work, King had caused special study to be made of the then developed mining districts of the West, more particularly of the Comstock Lode, at that time recognized as one of the three or four greatest silver deposits in the world. This work was pushed rapidly to completion and was issued in 1870 in an elaborately illustrated quarto volume, written conjointly by himself and James D. Hague, under the title of "Mining Industry." It was described by one of its most capable critics as by "itself a scientific manual of American precious metal mining and metallurgy." It was considered a classic among works in its line, and has served as a model for similar monographs since published under government auspices, which have been important factors in raising the mining industry of America to its present high position.

In July, 1870, while the members of his corps at New Haven were engaged in writing up the reports of what was supposed to be their completed field work, King received telegraphic instructions from General Humphreys to immediately take the field, since Congress, of its own impulse and without solicitation, now appreciating the importance of the work, had voted money for its further continuation. It being then too late in the season to carry on field work to advantage in the higher regions of the Rocky Mountains, King planned an exploration of the great extinct volcanoes of the Pacific coast in order to complete the record of the volcanic phenomena so abundantly exhibited within the area already surveyed in the Great Basin, and during the late summer and autumn special studies were made of the then practically unexplored peaks of Shasta, Rainier, and Hood.

The field work of the seasons of 1871-'2 carried the work of the Survey across the Uinta and Rocky Mountains well out onto the Great Plains. It was at the close of field work in the latter season that occurred the exposure of the great diamond fraud of

1872, an incident that brought into strong relief King's decision of character and readiness in an emergency and made him more widely and favorably known to the general public than any single act of his varied career.

News of an apparently well authenticated discovery of diamonds in sufficient quantity to affect the markets of the world had been circulated throughout the public prints during the entire summer. Its location had been kept carefully concealed, though it was generally assumed to be somewhere in Arizona. A company with ten millions of capital had been formed to work the diamond fields, whose stock had been freely subscribed to by some of the most prominent men in the East as well as the West, while a host of other companies were already organized ready to float their stock as soon as the position and character of the diamond-bearing rocks should become known.

Late in the autumn the writer and several other members of the 40th Parallel Survey, while on their way to San Francisco at the close of field work, became possessed of a number of clues, which though separately of the most indefinite character, when combined together enabled them, from their intimate knowledge of the country, to fix the location of the supposed discovery at a certain point within the area surveyed by him during the previous year. Whether by chance or intention, the location selected by the supposed discoverers had been singularly well chosen from a geological standpoint, for when asked where within that area diamonds would most probably be discovered, King at once fixed on that very region as the most probable one for their occurrence. It was because of its scientific importance that he decided upon an immediate investigation in spite of the lateness and inclemency of the season. It required over a week's travel for himself and assistants to reach the spot, and when, after several days' careful geological investigation, it was found that the diamonds could not have been placed there by Nature, King realized that a most cleverly planned fraud had been foisted on the public, which, if not promptly and conclusively exposed, would result not only in pecuniary loss to innocent investors, but in great suffering and even loss of life to the many that would probably rush to the bleak exposed region where the locations had been made. By journeying night and day across the

bad-land country he reached the railroad, and proceeding to San Francisco laid his facts before the managers of the company, offering to take to the spot with his own outfit any experts they might be willing to send to test the truth of his statements. Their journey was rendered doubly difficult by the great blizzard of that year that overtook them while in camp, but the company's engineers fully confirmed the conclusions arrived at by him and his party, and upon their return they were promptly made public by the officers of the company, thus averting what bid fair to be the most widespread and gigantic financial calamity that the world had seen since the Missouri Bubble of Law.

After the completion of field work of the Survey in 1873 there was necessarily a long delay before the abundant collections in the various scientific branches could be worked up by the respective specialists, the lithologic collections alone numbering about 5,000 specimens, for, under the high standards fixed for his work, it was only to the highest authorities in their respective branches that King was willing to entrust the final study of these collections.

Thus, under his instructions, the writer spent the summer of 1874 in Europe conferring with the heads of the leading European geological surveys as to their methods of work, and buying, at King's expense, the best and latest geological literature, with which at that time American libraries were but scantily provided. Furthermore, by personal persuasion he succeeded in inducing Professor F. Zirkel, the founder of the science of microscopical petrography, to visit America and study in the presence of the collectors their numerous collections of eruptive rock specimens, for at that time there was no geologist in America who had any practical knowledge of this new branch of geology.

King reserved for himself the final summarizing of the work of his assistants, and the drawing of general conclusions and theoretical deductions therefrom. This he did in the winter of 1877-'8 after the five government quartos and two great atlases embodying the details worked out by his various assistants had been printed. This summary was published in a volume, entitled "Systematic Geology," of over 800 pages, profusely illustrated by reproductions of photographic views illustrating typical geologic phenomena and analytical charts representing the im-

portant stages in the geological history of the Cordilleran system. It was probably the most masterly summary of a great piece of geological work that has ever been written, and was well characterized by its most competent critic in the following words:

"The most satisfactory part of Mr. King's work, next to its scientific thoroughness, is the breadth of view which embraces in one field the correlation of such extended forces and the vigor of grasp with which the author handles so large a subject without allowing himself to be crushed by details. Hitherto every geological report has been a geological itinerary without generalization or arrangement. This volume is much more; it is indeed almost a systematic geology in itself, and might be printed in cheaper form and used as a text-book in the technological schools."

Aside from the direct contributions to science embodied in the seven quarto volumes that contained the published results of this great survey, King exerted a most important influence upon geological work in this country by the high standards he set for it and his practical demonstration of the possibility of living up to them. Thus a topographic survey which should afford an accurate delineation of the relief of a country had not hitherto been considered a necessary base for geological mapping either in State or government surveys. A system of rapid surveying by triangulation and the use of contours to express relief was first employed by him in making maps of large areas, and inaugurated an improvement in our systems of cartography that has made the maps issued by our government superior to any in the world. He demonstrated the importance of the general use of photography as an adjunct to geology, which previously had not been considered practicable because of the labor and expense involved in transporting the necessary apparatus for the developing of wet plates in the field. Of even greater moment was the practical introduction of the methods of microscopical petrography, supplemented by chemical analysis, in the examination of rocks—an innovation which marked the opening of a new era in geological study in the United States.

His mind was possessed in a high degree of the quality, known as scientific imagination, that enabled it to grasp almost at a glance the ultimate bearing of observed phenomena on the

broader problems of geology, and thus he was often able to suggest to others profitable lines of investigation which he himself did not have time to follow out. Thus, during his study of the glaciers of Mt. Shasta, he made the observations that are credited with first suggesting the true origin of the kettle-holes and kames of New England, and his later discovery in the summer of 1874, that the line of islands extending along the southern coast of New England from the heel of Cape Cod to Staten Island contains remnants of the terminal moraine of the great glacier that once covered the northeastern States, had much influence in inducing the later systematic studies of the Continental glacier which have brought about the most important advance in the science of glaciology since the days of the elder Agassiz.

It had been the hope and ambition of King and his associates on the 40th Parallel that the quality and demonstrated usefulness of their work would be such that it would ultimately lead to the establishment of a general geological survey of the United States, whose permanence would be assured by being made a bureau of one of the executive departments of the government. This result came about much earlier than either of them had anticipated, and its accomplishment, singularly enough, was hastened by the zeal of rival leaders of different government surveys which it entirely superseded.

After two seasons of field work with the 40th Parallel Survey had demonstrated the practicability of geological map-making in the West, a second survey was inaugurated under the Engineer Department by Lieut. George M. Wheeler, which was designated "United States Geographical Surveys West of the 100th Meridian." In 1894 the already existing "Hayden Survey" adopted King's system of making topographic maps as a basis for its geology, employing for this purpose the topographers on the 40th Parallel after their work in the latter survey had been completed, and its title was changed to the "United States Geological and Geographical Surveys of the Territories." The fields of work of these organizations were not limited by any definite bounds, as had been that of the 40th Parallel, and with increasing popularity each became desirous of surveying the regions which contained the most remarkable and striking phenomena.

Thus their work often overlapped and was duplicated, and their rivalry finally became so intense that the influence of one party with Congress was used to curtail the appropriation allotted to the other. As a final result of this rivalry there was serious danger of a reaction in the feeling of Congress toward such surveys that would result in cutting off all government aid to geological work.

In this crisis King was appealed to as a disinterested party, and it was mainly through his influence with the leading scientific men of the country and his tactful management of affairs in Congress that the danger was averted. Congress was induced to call upon the National Academy of Sciences for its advice as to the best methods of carrying on the various scientific surveys which were then being conducted under different departments. Although a member of the Academy since 1876, King was not appointed on the committee to whom this question was referred, but was freely consulted by its members in making up their report.

By the law of March 3, 1879, the present United States Geological Survey was established as a bureau of the Interior Department, the exact language of the Academy's report being adopted so far as it related to geological surveys, and the previous organizations were thereby discontinued.

President Hayes, after consultation with the best scientists of the country, appointed Clarence King as the first director of the new Bureau. King accepted the appointment with the distinct understanding that he should remain at its head only long enough to appoint its staff, organize its work, and guide its forces into full activity. At the close of Hayes' term he offered his resignation, but at the President's request he held over until after the inauguration of Garfield. The latter accepted it on March 12, 1881, in an autograph letter expressing in the warmest terms his appreciation of the efficiency of King's service and his regret that he did not find it possible to remain longer in charge of the Geological Bureau.

Brief as was the duration of his administration, his influence being exercised at the critical period of the Survey's existence, left a lasting impress upon it. He outlined the broad, general principles upon which its work should be conducted, and its

subsequent success has been in a great measure dependent upon the faithfulness with which these principles have been followed by his successors. His belief was that a geological survey of a great industrial country, while not neglecting the more purely scientific side of its work, should occupy itself primarily with the direct application of geological results to the development of the mineral resources of the country.

Under his direction were carried on the examinations of the Comstock, Eureka, Leadville, and other mining districts, whose importance is to be measured not solely by the accurate information which they afforded of these particular regions, but in far greater degree by their influence upon the whole body of mining engineers, in teaching them the practical importance of a study of the geological relations of ore deposits.

He also planned and supervised the collection of statistics of the precious metals for the Tenth Census, a work which has never been equaled in detail or scientific accuracy, and whose logical result was the annual collection of statistics of all the mineral resources of the United States, which has been carried on by the Geological Survey ever since the completion of the work of the Tenth Census.

King set the very highest standard for the work of the Survey and showed remarkable judgment and knowledge of character in his selection of the men who in their respective branches were best fitted to keep it up, as nearly as possible, to this standard. In his establishment of a physical laboratory for the determination of the physical constants of rocks, he took a step in the direction of the application of methods of exact science to geological problems so far in advance of the average standards of the day that its importance was not generally realized until long after.

In all his after life he maintained a lively interest in the work of the Survey and kept closely in touch with his successors in office, who frequently consulted him on important questions of policy.

In giving up his official connection with government geological work, King was doubtless influenced by several motives: His many years of strenuous work and unusual responsibility had been a severe strain upon his health, and he felt the need of rest

and change. Moreover, he was confident that he could render a greater service to geological science by pursuing the theoretical researches into its deeper problems, for which the physical laboratory he had established would in time furnish the necessary data, than by devoting his time and strength to administrative duties. Financial considerations doubtless had some weight also, for under the new law his official position shut him out from any professional remuneration beyond his salary, and that was not sufficient to enable him to meet the obligations he felt it incumbent upon him to assume for others.

During the remaining twenty years of his life much of his time was necessarily given to private professional work, either in personally managing and developing mining properties or acting as adviser for others. In this work his ambition was to accumulate sufficient capital to enable him to pursue unrestrainedly the necessarily expensive experiments needful for the carrying out of his chosen line of investigation, and to insure the comfort of those depending upon him. Freed from the confinement and responsibilities of the administration of a great survey, he was, moreover, now able to devote more of his time to the cultivation and indulgence of his pronounced literary and artistic tastes; but his scientific investigations, though of necessity frequently interrupted, were ever present in his mind, and never, as some have erroneously assumed, abandoned.

In 1882, being called to London on business connected with some large Mexican mining companies, of which he was president, he came into familiar converse with the leaders of the scientific and literary circles of that great intellectual center, to whom his work was already well and favorably known and his charming personality soon endeared him.

The greater part of the next two years was spent there and in traveling extensively on the continent. While he naturally came into contact with most of the prominent scientific men in Europe and recalled with special pleasure his intercourse with Sir William Thomson (now Lord Kelvin), whose investigations into terrestrial physics had early attracted his attention and excited his admiration, he was perhaps even more widely known and admired in Europe for his literary and social qualities and as a connoisseur of art.

In 1890 Brown University conferred upon him the honorary degree of LL.D. That he received no public recognition of his later scientific work may perhaps be ascribed to its peculiarly unobtrusive character, which gave rise to the erroneous impression that he had abandoned science altogether.

In 1892 he wrote the only scientific publication of his later years on the "Age of the Earth," which appeared in the *American Journal of Science* in 1893. It is the latest and perhaps one of the most profound discussions from the point of view of terrestrial physics of that important subject, and was most favorably received by such great physicists as Kelvin and Helmholtz.

By the great financial disaster of 1893 King, in common with many others, suffered severe financial losses, and by the failure of a national bank which he had founded the greater part of his accumulations of previous years were swept away. In the following winter, during convalescence from a serious attack of nervous prostration, he spent several months in Cuba at the country house of his friend, Henry Adams, the historian, during which he became deeply interested in the political condition of the island and visited the camps of the revolutionists, thus becoming personally acquainted with their chiefs. The sympathy with their cause which resulted from his investigations led him to actively espouse it during the discussions in this country which led up to the Spanish war, both in personal interviews with the leaders of the administration and in published articles in the "Forum."

He also investigated the geology and economic resources of the island, which so interested him that it became one of his cherished plans of future work to organize a geological survey in Cuba, if political conditions should become sufficiently settled to justify it.

During his later years the great stimulation of mining industry of this country led to an ever-increasing demand for his services, both as expert in important mining investigations and in passing on the value of properties offered as investments to capitalists, demands which he did not feel justified in refusing. Such work often involved the most severe and even dangerous strain, and in this, as in everything else in which he was engaged, King never spared himself.

In January, 1901, he undertook the examination of a mining property in Missouri which had been sold to English capitalists subject to his approval. An attack of whooping cough and pneumonia in the previous month had left him with a slight tubercular affection of one lung. The weather was inclement and the examination proved unusually long and laborious, so that at its close it was found that tuberculosis had taken so firm a hold upon his system that he was obliged to abandon all business and give himself up entirely to the attempt to recover his health.

After a fruitless visit to the tropics, which had hitherto proved a balm for all of his ailments, he attended the annual meeting of the Academy in April, 1901, and then went West, where he spent the balance of the year in southern California and Arizona in a brave though hopeless fight against the inroads of the dread disease.

In this, with a thorough understanding of the probable outcome of his illness, he displayed the same cheerful courage and spirit of self-renunciation that had characterized his whole life. He would not yield to the desire of his devoted mother to hasten to his bedside, fearing the effect of the long journey in her then precarious condition of health, and he courteously declined the many offers of his friends to visit him and cheer his loneliness. On Christmas eve of 1901, at Phœnix, Arizona, he finally passed away, quietly and without suffering, in the prime of intellectual life, with his greatest scientific work not yet fully completed and leaving a void in the hearts of friends that can never be filled.

It is difficult to fairly judge King's scientific publications in the light of the present day, for they were written just before the opening of an era of great change in the methods of geological investigation—a change which has thus far proved destructive rather than constructive in its results. Many of the fundamental theories of geology which prevailed at that time have been disproved or abandoned, while as yet there is no general acceptance of those which have been put forward to replace them.

In June, 1877, he delivered the address at the 31st anniversary of the Sheffield Scientific School on "Catastrophism and the

Evolution of Environment." It was a protest against the extreme uniformitarianism of that day, based largely on the geological history of the Cordilleran System as developed during the work of the 40th Parallel Survey. This uniformitarianism he characteristically described as "the harmless undestructive rate (of geological change) of today, prolonged backward into the deep past." He contended that while the old belief in catastrophic changes had properly disappeared, yet geological history, as he read it, showed that the rate of change had not been so uniform as was claimed by the later school. While a given amount of energy must evidently be expended, he reasoned, to produce a given effect, yet the expenditure of this energy might be extended over a very long time or crowded into a comparatively short one; and his observations showed him that at certain periods in geological history the rate of change was accelerated to such a degree that the effect upon life produced was somewhat catastrophic in its nature.

Of his great work upon Systematic Geology, the larger part—that which outlines the geological history of the Cordilleran system—stands as firmly today as it did when written, as a correct and authoritative exposition. In view of the circumstances under which the field work was originally done, its essential correctness, even in matters of minor detail, is considered surprising by those who have since had occasion to make detailed studies of portions of the area covered.

In the more theoretical sections, while he necessarily did not take into account the great number of new facts which have been established by more recent work, especially in the domain of microscopic petrography, he showed such grasp of his subjects and such originality and power of thought that his views constituted not only an important advance over those of the day, but they were suggestive of the lines of investigation that have been most fruitful in the modern advance of geological science.

For instance, in his discussion of the reason for the changes from acid to basic eruptives within the individual groups, which he proposed as a variation from the natural order in age of volcanic rocks, as laid down by Richthofen, he advanced views very suggestive of the modern conception of differentiation in eruptive magmas.

Again, in endeavoring to account for the formation of those types of granite that pass into gneiss and crystalline schists of essentially the same chemical composition, but which show no evidence of having been subjected to such excessive heat as would produce actual liquefaction, he called in the agency of the immense pressure to which such rocks would necessarily have been subjected. While the long years of combined field work and microscopic study of modern petrographers, made since King's theory was enunciated, have proved that the structure of crystalline schists *is* due to pressure, they do not go so far as he did in assuming that the end product of such mechanical pressure might be granite.

Perhaps his most enduring theoretical discussion of that time was that on hypogeal fusion, in which, accepting the validity of the physical arguments against the fluid interior of the earth, he discusses and rejects Hopkins' theory of residual lakes and Mallett's conception of local lakes produced by mechanical crushing. He then advances an hypothesis of his own which may be called that of a critical shell, or *couche,* between the permanently solid interior and the outer crust of the earth, which is above the temperature of fusion but restrained from fusion by pressure. In this, therefore, the opposing forces of pressure and temperature hold themselves reciprocally in equilibrium, but when this equilibrium is disturbed, as, for instance, by a sudden change of the relative position of isobars and isotherms—say by local erosion and rapid transfer of load within limited areas—local lakes of fusion would be created. Iddings, in his "Origin of Igneous Rocks," says of King's treatment of this subject: "By the breadth of his treatment and by better and fuller data he advanced the problem of the origin of the various kinds of volcanic rocks far beyond the point reached by any of his predecessors."

In his chapter on Orography, King says, in speaking of the causes of crust motion: "I can plainly see that were the critical shell established its reactions might thread the tangled maze of phenomena successfully, but I prefer to build no farther until the underlying physics are worked out." He was at that time already very strongly impressed with the imperfection of the then existing knowledge of terrestrial thermo-dynamics and the

indispensability of more exact data in this branch of science for a rational discussion of the fundamental problems of geology.

This idea found a practical outcome a few years later in the establishment of a physical laboratory, immediately after his assumption of the Directorship of the United States Geological Survey. His earnestness and energy is shown by the fact that instead of waiting for the slow action of Congress, he defrayed the cost of the delicate apparatus necessary for this work out of his own pocket. The credit of the brilliant physical investigations carried on in that laboratory is naturally due to Professors Barus and Hallock, who conducted them, but it was King's acumen and good judgment that was responsible for their selection, and his action that made it possible for them to carry on their work. To himself, as he says ten years later in his paper on the Age of the Earth (Am. Jour. Sci., vol. xlv, January, 1893), he reserved the privilege of "making geological applications of the laboratory results." The experiments on the physical constants of rocks contemplated were to be directed to the determination (*a*) of the phenomena of fusion, (*b*) of those of elasticity and viscosity, and (*c*) of those of heat conductivity, each considered with special reference to their dependence on temperature and pressure.

The paper on the Age of the Earth, mentioned above, is his only published result, and was but an earnest of what he had planned to do. This was an attempt to advance to new precision Kelvin's estimate of the earth's age deduced from terrestrial refrigeration. It consists mainly of a mathematical discussion of the earth's thermal age as determined from various postulates presented by Laplace, George H. Darwin, and Lord Kelvin, and based on Barus' determinations of the latent heat of fusion, specific heat, melted and solid, and volume of expansion between the solid and melted state, of the rock diabase. This is followed by a critical examination of other methods of determining the earth's age—by tidal retardation, by sun-age, and by variations of eccentricity. After a careful scrutiny of all the data on the effect of pressure on the temperature of consolidation, King concluded that, without further experimental data, "we have no warrant for extending the earth's age beyond 24 millions of years," an estimate which, as the result of a somewhat more ex-

tended discussion, was afterwards confirmed by Lord Kelvin himself. (Smithsonian Report, 1897, p. 345.)

His further investigations along the same general lines on the fundamental principles of upheaval and subsidence were in an advanced stage of completion when they were cut off by his untimely death.

It is practically impossible to adequately characterize King's literary work, for the greater part of what he did was never published, and very likely never even written. It was his habit to work out in his head any subject which interested him, even down to its minutest details, before putting a pen to paper; once this was accomplished to his satisfaction, he wrote with such ease and rapidity that the words actually flowed from his pen. Probably one reason that he did not write more was that his own literary taste was so refined and exacting that he was never thoroughly satisfied with his own conceptions. In his scientific writing, there was generally some imperious necessity that made it urgent upon him to give his results to the public in spite of the imperfections he might still see in them, but in literature such necessity rarely appeared. What he did publish he himself held in comparatively light esteem, but in the opinion of the best literary writers of the day, with most of whom he was on terms of friendly and intimate intercourse, his writings, and even more his affluent and delightful talks, disclosed a literary quality that might have given him a foremost place among American men of letters.

His one literary book, "Mountaineering in the Sierra Nevada," went through more editions in England than in this country, and was very generally regarded there as far the best book of its kind that had ever been written. Of it Edward Cary, one of our most discriminating literary critics, has said:

"There is in these pages a vital harmony between the subject-matter and the form. It cannot be analyzed; much less can it be described or accounted for; least of all can it be resisted. It stimulates and energizes, while it charms the mind. It gives, in its own way and in its field, an intelligent reaction akin to that given by certain passages of Shakespeare in which he explores the depths of human consciousness, and every inflection,

every cadence thrills with the solemnity and the vastness of the subject."

Of his occasional articles in current periodicals, two appeared in the *Century* in 1886, two in the *North American Review*, and three in *Forum*. Of the latter, two on Cuba, published in the years immediately preceding the Spanish War, were written under the impulse of strong feelings of sympathy with the cause of the insurgents, with whom he had come into intimate personal contact during the winter he spent on the island.

Of his *Century* articles, one was a delicate tribute to his closest friend, John Hay, as one of the biographers of Lincoln; the other, a short sketch of his search for the "Helmet of Mambrino" for a fellow-Cervantista, was that which more than anything he ever published disclosed the exquisite delicacy of his literary touch, which rivaled that of Howells or James and showed an even rarer and more refined quality of wit than Bret Harte's.

The best idea of the estimation in which he was held by his many friends and associates in the literary and artistic world may be obtained from the following quotation from the necrology of the Century Association of New York, of which he had been a prominent member for the last quarter of a century:

"He was himself a blend of varied qualities and gifts that were not always ready to keep the peace one with another, but the collective manifestation of which was to his fellows a constant joy. The talk he made or evoked may be equaled by those who are to come after; it can never be matched. Its range was literally incalculable. It was impossible to foresee at what point his tangential fancy would change its course. From the true rhythm of Creole gumbo to the verse of Theocritus, from the origin of the latest *mot* to the age of the globe, from the soar or slump of the day's market to the method of Lippo Lippi, from the lightest play on words to the subtlest philosophy, he passed with buoyant step and head erect, sometimes with audacity that invited disaster, often with profound penetration and with the informing flash of genius. It is but a suggestion of his rare equipment to say that in his talk, as in his work, his imagination was his dominant, at moments his dominating quality. Intense, restless, wide-reaching, nourished by much reading, trained in

the exercise of an exact and exacting profession, stimulated by commerce with many lands and races, it played incessantly on the topic of the moment and on the remotest and most complex problems of the earth and the dwellers thereon. And within a nature brilliant and efficient beyond all common limits glowed the modest and steady light of a kindness the most unfailing and delicate. The good one hand did he let not the other know; both were always busy, laying in many lives the foundations of tender and lasting remembrance."

The following list comprises the principal published works of Clarence King:

Mountaineering in the Sierra Nevada. Boston, 1870.

Mining Industry (by James D. Hague, with geological contributions by Clarence King), vol. III of the Fortieth Parallel Reports. Government Printing Office, Washington, 1870.

Active Glaciers within the United States. *Atlantic Monthly*, March, 1871.

On the Discovery of Actual Glaciers on the Mountains of the Pacific Slope. *Am. Jour. Sci.*, 3d ser., vol. I, p. 157. 1871.

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Style and the Monument. *North Am. Review*, November, 1885. (An article on the proposed Grant monument—anonymous, but known by friends of Mr. King to have been written by him.)

Artium Magister. *North Am. Review*, October, 1888.

The Age of the Earth. *Amer. Jour. Sci.*, vol. XLV, January, 1893.

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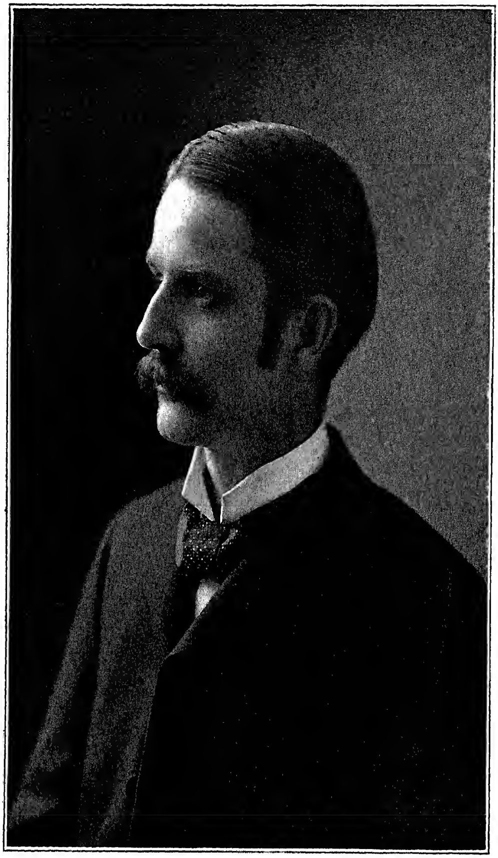

Charles E. Beecher.

BIOGRAPHICAL MEMOIR

OF

CHARLES EMERSON BEECHER.

1856–1904.

BY

WILLIAM HEALEY DALL.

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
NOVEMBER 16, 1904.

BIOGRAPHICAL MEMOIR OF CHAS. EMERSON BEECHER.

CHARLES EMERSON BEECHER, eldest son of Moses and Emily (Downer) Beecher, was born in Dunkirk, New York, October 9, 1856.

The mother of Moses Beecher was a Dawson, originally from England. On the Emerson side, the great-grandfather of Charles, Richard Emerson, was from Spofford, New Hampshire, and his wife was Mary Gorton, a direct descendant of Samuel Gorton, of Rhode Island. They moved to Otsego county, New York, in 1749.

Moses Beecher was a banker, and is remembered as a courtly gentleman of the old school, a man of education and refinement. He and his wife were considered persons of more than ordinary cultivation and attainments. Five children, four boys and a girl, were born to them, of whom one brother survives in California.

In the early childhood of Charles his parents removed to Warren, Pennsylvania, where the boy attended private grammar and the public high schools. The surroundings were favorable, the rocks of the vicinity rich in fossils, and at the age of twelve years he began making a collection of the local fossils. Perhaps, as he was always delicate, his parents may have encouraged him as a means of keeping him as much as possible in the open air. At all events, he became much interested, and amassed from the Chemung and Waverley formations of Warren a choice and extensive collection. These tastes soon led him to extend his studies to the minerals and recent shells, in which he always remained interested.

Later he took the scientific course at Michigan University, receiving in 1878 the degree of B. S. from that institution. The late Prof. James Hall, of Albany, kept a watchful eye on all students and collectors of fossils, and, after graduation, young Beecher went to Albany almost immediately, where he was engaged as assistant in the New York State Museum directed by

Professor Hall, and affording unrivaled opportunities for the study of American paleozoic invertebrates. During the ten years spent here by young Beecher he not only became proficient to a remarkable degree in knowledge of the New York faunas, but, having a natural facility in mechanical matters and the use of tools, he became an exceptionally fine preparator of fossils, and always enjoyed the process of disentangling a complicated fossil from its matrix, or the revelations of the saw in making serial sections. Some of the preparations of groups of trilobites left by him in the State Museum are marvels of well-directed and successful effort. In such things he took the pride of a successful craftsman who knows that his work is good.

His first scientific papers were written in coöperation with others, and treated of the recent mollusks. After going to Albany he continued to collect and study the local fauna. These, together with material collected at Warren and near Ann Arbor, or obtained by exchanges, amounting in all to about twenty thousand specimens, he gave to the New York State Museum in 1886 and 1887.

Beside work on the collections at Albany he rendered, according to Prof. James Hall, important assistance to that gentleman in the preparation of his great monographs of the different groups of invertebrates from the New York rocks, especially the Mollusks, Polyzoa, and Corals. These works were printed by the State of New York, and in the prefaces ample acknowledgments are made of Beecher's services.

Always skillful as a draftsman, he added to his small salary from the State by making drawings for professional men at Albany, and most of his papers were illustrated by his own hand. His vacations were spent at localities where collections could be made, especially the richly fossiliferous beds of the Helderberg Mountains, near Albany, New York. Of his collections here Professor Jackson remarks:*

"Indian Ladder," in the Helderberg Mountains, was always a favorite and fertile spot for him, dating back to his Albany days. It is one of the most beautiful and picturesque regions in the Helderbergs. He collected there slabs of limestone containing

*American Naturalist, vol. XXXVIII, No. 450, p. 411.

fossils which were silicified in the most perfect condition for development by etching with acid. From such materials he obtained specimens of surpassing beauty and scientific interest. Beside adult fronds of Bryozoa, Brachiopoda, Crustacea, and other fossils in most perfect preservation, he obtained minute embryos and small species in large numbers in literally wonderful condition of perfection. Young *Bilobites* half a millimeter in length, young *Acidaspis* 0.83 millimeter, and *Arges* 1.15 millimeters long, both of the latter so perfect that he figured them from both the dorsal and the ventral aspects; young *Pleurodictyon* consisting of the initial cup alone, and also others with the first lateral buds; young *Bryozoa* showing initial chambers. Such material, selected with infinite care and patience, formed the basis of a number of papers by Beecher and others.

At this period Beecher published independently a paper on Phyllocarida, a group in which he never lost interest, from material collected by him at Warren, Pennsylvania; and several papers on the recent Rissoidæ. His most important work of this period was based on Brachiopoda obtained from the clays of Waldron, Indiana, in which he was associated with John M. Clarke. This paper is one of the first on the development of Paleozoic Brachiopoda, and opened up several new lines of investigation.

In 1888 Prof. O. C. Marsh, of New Haven, induced Beecher to accept the position of Assistant in Paleontology at the Peabody Museum of Yale University, though for a time he was also named Consulting Paleontologist to the Museum at Albany, and returned there from time to time in connection with the duties of this honorary position. He also pursued his studies at Yale, under Dana, for the degree of Ph. D., which was conferred upon him in 1889, his doctoral thesis treating of the Brachio-spongiidæ, a group of fossil sponges of which the Yale Museum has an unusually fine series. Owing to the illness of Professor Dana, in 1891, Beecher took charge of the classes in Geology during that and the following year, when he was made Instructor in Paleontology, and later Assistant Professor of Paleontology, becoming in 1897 Professor of Historical Geology and a member of the Governing Board of the Sheffield Scientific School of Yale University.

Professor Marsh recognized Beecher's ability and appreciated his loyalty as assistant in the Museum, which on the Paleontological and Geological side Marsh effectively controlled during his lifetime. On Marsh's death, in 1899, Beecher succeeded him as curator of the geological collections, and was made a member of and secretary to the Board of Trustees of the Museum. He then undertook to arrange, develop, and place on exhibition the Marsh collection of fossil vertebrates. This work was done under his direction, though he personally had much to do with the large mounts of *Claosaurus* and *Brontosaurus*, the former of which he has described at length in a paper published by the Connecticut Academy in its Transactions.

In June, 1899, Beecher gave his large and very valuable collection of fossils to the Peabody Museum, as he expressed it, "in grateful recognition of the honors and favors conferred upon me during my connection with the University." These collections comprised over 100,000 specimens and about five hundred types, which had served as a basis for publications by the States of New York and Pennsylvania and various scientific periodicals. The material was chiefly from the Devonian and Lower Carboniferous of the two States mentioned, and represented the private labor, outside of his official working hours, for some twenty years.

"Already interested in studies of the development of organisms from his work on the development of Silurian brachiopods, in 1889 Beecher became deeply interested in the late Professor Hyatt's methods of work—the application of the principles of stages in development, acceleration, parallelism, and dynamic genesis to the unraveling of the genealogical relations of living and fossil animals. Bringing to this work his large and intimate knowledge of species and the structure of fossil types, Beecher entered into this field with characteristic energy and became a leader of the Hyatt school. Beecher's reputation as an investigator will rest chiefly on the rich results he obtained in the critical, painstaking application of those fruitful principles that Professor Hyatt labored so long to establish."*

* R. T. Jackson in American Naturalist for June, 1904. This article and Professor Schuchert's memoir in the American Journal of Science for the same month have been freely laid under contribution for the purposes of the present memoir.

"To Beecher we owe the first natural classification of the Brachiopoda and Trilobita based on the law of recapitulation and on chronogenesis. He also gave a very philosophic account as to the origin and significance of spines in plants and animals. On these works his reputation in days to come will chiefly rest."*

In 1893 there was discovered in the Utica formation near Rome, New York, a band, not over one-fourth of an inch thick, in which occur the trilobites *Triarthrus* and *Trinucleus*, exquisitely preserved as pseudomorphs in iron pyrite, retaining antennæ and legs and many of the more delicate parts. This discovery, by W. S. Valiant, afforded a hitherto unparalleled opportunity for the study of these animals. Two specimens of Trilobites with legs had been previously known; W. D. Mathew had announced the presence of antennæ, and Walcott by laborious serial sections had determined the number and approximate form of the legs and gills in a number of species. Now, however, a vastly better opportunity for precise observation of the details of the structure of these animals was presented. Beecher took out several tons of the shale and, aided by his remarkable manual dexterity, mechanical skill, and untiring patience, worked out the structure of antennæ, legs, and other ventral appendages with a minuteness which had previously been impossible. Since 1893 he published fifteen papers on the Trilobites, including in 1897 a classification based on these studies, in which the group was divided into three orders, founded chiefly on the development of the free cheeks. At the time of his death he was at work on an extensive monograph of Trilobite structure. He regarded these animals as forming a subclass equal in rank to the Entomostraca and Malacostraca, stating that in nearly every particular "the Trilobite is very primitive and closely agrees with the theoretical crustacean ancestor. Its affinities are with both the other subclasses, especially their lower orders, but its position is not intermediate." More than five hundred specimens of *Trinucleus* and *Triarthrus* were prepared by him, and Schuchert observes that few can appreciate the remarkable talent displayed in clearing the adhering black shale from these small specimens, and that it will be a long time before his equal in this delicate work is likely to appear.

* Charles Schuchert, op. cit.

Beside his works on the Corals, Brachiopods, and Trilobites above referred to, he became in 1892 deeply interested in the significance of spines, accumulating material till 1898, when he published his memoir entitled "The origin and significance of spines," the longest of his papers and the one, according to Schuchert, which he regarded as his best and most philosophic work.

Fortunately for students of Paleontology, most of Beecher's more important papers were reissued in one volume in the Yale Bicentennial series, entitled "Studies in Evolution." He himself regarded the reprinting of already published papers as a kind of extravagance; but those interested in philosophical zoölogy will feel grateful for the combination of so many important contributions to it in the compass of one volume. His views on the classification of the Brachiopoda and Trilobita are incorporated in the translation by Eastman of Zittel's *Grundzüge der Palæontologie*.

In his bachelor days at New Haven, Beecher, with Pirsson, Penfield, and Wells, roomed in "The Attic," the top story of the Sheffield Scientific School, which was comfortably fitted up in true Bohemian style; and Jackson recalls as one of the pleasantest recollections of a visit to New Haven the memory of calls at "The Attic," where, after working hours, delightful intercourse, social and scientific, was held, often far into the night. After moving to New Haven, Beecher made his single journey abroad in company with the late Dr. George Baur, visiting many European museums.

September 12, 1894, Professor Beecher married Miss Mary Salome Galligan, of Warren, Pennsylvania, who, with two daughters, his mother, and one brother, survives him.

Always delicate, of medium height, dark hair and eyes, and apparently good physique, Professor Beecher had the aspect of a man whose years might be long in the land, and of late had seemed to enjoy excellent health, but he died suddenly, from an affection of the heart, February 14, 1904, with no warning to soften the blow to those who loved him. His remains lie in Grove Street Cemetery, New Haven, in the shadow of the Sheffield Scientific School.

The director of the school has said of him: "Quiet and unas-

suming, he never sought adulation, but when there was earnest work to be done, requiring skill, patience, and good judgment, he would labor quietly and industriously, bringing to bear upon the problem such a measure of common sense and of thoughtfulness that confidence in and respect for his conclusions were inevitable. * * * No matter how trivial the duty, it was always done at the appointed time, and thoroughly done. * * * As a friend he was loyal and trustworthy, and his memory will always be cherished by his associates in the Sheffield Scientific School."

One of his pupils has testified to the inspiration given by him to his students, and how his patience, perseverance, and ingenuity served as an incentive to his associates, who were drawn closely to him by his enthusiasm and entire lack of egotism.

There is no doubt that in the death of Professor Beecher not only has Yale sustained a serious loss and Paleontology a severe blow, but the ranks of those capable of bringing to the study of fossils keen insight and a philosophical spirit of inquiry, guided by principles whose value can hardly be exaggerated, are diminished by one whom science could ill afford to lose and to whom, humanly speaking, there should have remained many years of industrious and fruitful research.

MEMBERSHIP IN SCIENTIFIC SOCIETIES.

Ann Arbor Scientific Association.
Albany Institute.
New York Microscopical Society.
American Association of Conchologists.
Connecticut Academy of Arts and Sciences.
Berzelius Society, New Haven, Connecticut (honorary).
Dana Natural History Society, Albany, New York (honorary).
Geological Society of Washington, D. C.
Sigma Xi, New Haven, Connecticut.
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Yours truly
G. O. [illegible]

BIOGRAPHICAL MEMOIR

OF

GEORGE PERKINS MARSH.

1801-1882.

BY

WILLIAM M. DAVIS.

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL 18, 1906.

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BIOGRAPHICAL MEMOIR OF GEORGE PERKINS MARSH.

GEORGE PERKINS MARSH* was born in Woodstock, Vermont, March 15, 1801, the son of the Hon. Charles Marsh and his second wife, the daughter of Elisha Perkins, of Plainfield, Connecticut. His ancestor, John Marsh, came from England to Massachusetts in 1633, and in 1635 removed to Lebanon, Connecticut; and his grandfather, Joseph Marsh, was an early settler in the "New Hampshire grants"—afterwards Vermont—where, in 1778, he was the first lieutenant governor of the new State.

Marsh's boyhood was passed in the vigorous life of a hilly country. He narrates that in his fifth year he sat on a little stool between his father's knees in a two-wheeled chaise:

"My father pointed out the most striking trees as we passed them, and told me how to distinguish their varieties. I do not think I ever afterward failed to know one forest tree from another. * * * He pointed out the direction of the different ranges of hills; told me how the water gathered on them and ran down their sides. * * * He stopped his horse on the top of a steep hill, bade me notice how the water there flowed in different directions, and told me that such a point was called a watershed. I never forgot that word, nor any part of my father's talk that day."

At seven the boy used to lay a volume of the Encyclopædia Britannica on the floor, lean over it on his elbows, and read it for hours at a time, to the point of injuring his eyes, from which he long afterwards suffered. After brief preparatory studies at Phillips Andover Academy, he entered Dartmouth College in 1816, where he was known as an assiduous student, chiefly in ancient and modern languages, and where he was graduated with

* The following memoir is based chiefly on the "Life and Letters of George Perkins Marsh," by his widow, Caroline Crane Marsh (New York, Scribner, 1888—only vol. I published); a "Discourse Commemorative of the Hon. George Perkins Marsh," by Samuel Gilman Brown, delivered at Dartmouth College and at the University of Vermont in 1883, and a "Bibliography" by H. L. Koopman (Burlington, Vermont, 1892).

highest honors in 1820. After a brief and unsuccessful period as a teacher at a military academy in Norwich, Vermont, he returned home to study law with his father, and was admitted to the bar in 1825. He then removed to Burlington, Vermont, where his cousin, James Marsh, was president of the University of Vermont, and where he divided his time between the practice of his profession and literary studies. Here, in 1828, he married Harriet Buell, who died in 1833; he married again in 1839, his second wife being Caroline Crane, of Berkley, Massachusetts, who survived him. In 1835 he was elected to the Supreme Executive Council of Vermont, one of thirteen members—there was then no State senate—and in 1837 he made a journey to the upper Mississippi Valley as far as the Falls of St. Anthony. Returning to his eastern home, he became interested in the establishment of a woolen manufactury at Winooski, and at the same time took up the study of the languages of Northern Europe, as a result of which he published in 1838 "A Compendious Grammar of the Old-Northern or Icelandic Language, compiled and translated from the grammars of Rask." This book, representing "much original work, especially in the sections devoted to inflections and in the treatment of the syntax," was printed in the author's absence, and contained so many typographical errors that it was never placed on sale. He shortly afterwards delivered an address on "The Goths in New England," which excited much attention; and it was in this connection that he later pointed out, when speaking before the New England Society of New York, that our forefathers were fortunately harried out of England before their "character had become enervated or its energies spent."

In 1843 Marsh was elected to Congress and spent the following seven years, a period of great political excitement, in Washington. A number of his speeches attracted notice. In 1844 he spoke in favor of a protective tariff, being doubtless moved thereto by the hope of developing the growth and manufacture of wool in Vermont. In 1845 he made a strong argument against the admission of Texas as a slave State, and at that early time said to one of his friends: "Texas means civil war before we have done with it." In 1848 he protested against the continuation of the Mexican War, which he characterized as a national crime.

He was an early riser and hard worker during these political years and took some of his needed rest by sleeping in the House—as did J. Q. Adams also—during the speeches of such fellow-members as he did not care to hear. It was during this period that he addressed the Phi Beta Kappa societies at Dartmouth in 1844 and at Harvard in 1847.

Several life-long friendships were developed from the acquaintance made in Washington. Among those with whom he became most intimate was Colonel, afterwards Sir James Estcourt, British Boundary Commissioner, who with Lady Estcourt seems to have given Marsh and his wife a different opinion of English people from that which they had previously conceived in a provincial American spirit. While serving on a committee to report a bill for the establishment of what has come to be known as the Smithsonian Institution, Marsh met a number of the scientific men then in Washington, and of these Spencer F. Baird became his intimate associate and correspondent. The letters addressed by Marsh to Estcourt and to Baird in later years afford a pleasing insight into his versatile character. The letters to the Estcourts, although phrased in a familiar style, seldom depart from courteous formality. The letters to Baird are full of fun and nonsense, in which the writer seems to have found much entertainment. A New Year's greeting in 1859 wished Baird "thousands of letters less to write. 'Tis the pestilentest, most soul-destroying occupation on earth, that is, when you have anything to write about. But to scribble about nothing, as we used to do before we came to be such a couple of sapless dry old sticks as time, trouble, and Satan have made us, is good. It prolongeth life, health and youth, driveth away blue devils and red, and comforteth the inward man exceedingly." Again: "I don't know where I shall be, but if you blow a tin horn about once in half an hour all summer long, I shall probably come within hearing of it, and will go to you." Some of these letters begin "My Dear Boy;" and once, when Baird was visiting Sing Sing, a letter to him opened with "Unfortunate Youth."

In 1849 Marsh was appointed Minister to Turkey, where no American has made a better impression. On his arrival at Constantinople it is stated that he could speak "with the representatives of France, Germany, Italy, Sweden, Denmark, and

Norway in their own tongues;" he soon learned to speak Turkish also and made some progress in Arabic and Persian. These unusual linguistic accomplishments as well as his strong personal character gave Marsh a marked eminence among the other members of the diplomatic circle, although his diplomatic rank was below that of every other European minister, from however small a country. In 1851 he made a journey up the Nile as far as the second cataract, collecting specimens for Baird on the way, and then undertook a long trip on camels from Cairo into Palestine. In 1852 he was given a special mission to Athens in behalf of an American who had been unjustly treated there; he thus had to study out a great body of legal records, largely in the form of modern Greek manuscript, and he afterwards said that in no part of his life had his labor been so severe as in those hot months. Fortunately his mission was successful. The change in administration at Washington in 1853 resulted in the recall of this valuable public servant, and after a return journey through southern Europe he made his home again in Burlington. The following period was harassed with business difficulties, for his affairs had not prospered during the absence in Turkey. Some relief came in 1857 when he was appointed railroad commissioner for Vermont, but full relief was not reached until 1861, when after long delayed action he received a considerable sum of money from Congress in payment of his claim for work during his special mission to Athens, ten years before. Regarding this he wrote: "I am very glad to learn the passage of my bill. The amount will just about pay what I owe, and leave me penniless and contented." His business embarrassments had indeed been for a time so serious that they caused him to decline with much regret the offer of a professorship of history at Harvard College in 1855; he did not feel that he could turn away from his affairs at Burlington, where his creditors had left everything in his hands, to be made the most of. He had, however, some relaxation from business in the preparation of a book on "The Camel, * * * with reference to his introduction into the United States" (Boston, 1856), in which much of his eastern experience was recalled; and he seems to have derived great satisfaction in delivering in 1858 to the graduate students at Columbia College a course of "Lectures on the English language" (New York, 1860;

revised edition, 1885), in which "he dwelt much on the value of etymology, and especially on the importance of tracing the individual history of words in their actual use, from their first recognized appearance to their present employment or their final disappearance." During the winter of 1860-'61 he gave before the Lowell Institute in Boston a series of lectures on "The origin and history of the English language and of the early literature that it embodies" (New York, 1862; revised edition, 1885). Both of these books give evidence of unusual erudition and of keen interpretation, and were highly valued by literary students. It was during the visit to Boston that Marsh wrote, after a dinner with the "Atlantic" Club: "These dinners make me most keenly sensible of what I have lost intellectually by the want of more frequent opportunities of meeting with persons of high culture." Regarding the secession of the Southern States from the Union, then threatened, Marsh wrote: "I take it to be quite certain that the Cotton States will accept no terms which the people of the North can or ought to propose. * * * I have no hope of a peaceable adjustment of this controversy. * * * I do not believe that a division of the Union is feasible. The States are a geographical and must be a political unit."

Early in 1861 Marsh was appointed by Lincoln minister to the new Kingdom of Italy; he was the first American minister to the first king. This important position was held at Turin, Florence, and Rome, with great acceptance to Italians and Americans alike, for twenty-one years, until his death, in 1882—a length of continuous foreign service as minister that is said to be unparalleled in our diplomatic service. The only volume of his "Life and Letters" that has been published unfortunately closes with his departure for Italy, and it is therefore difficult to obtain adequate material for an account of these interesting later years, during which Marsh greatly increased his acquaintance with men worth knowing, accumulated a large library and made diligent use of it, and became known to scientific men as the author of an important geographical work.

Marsh was at this time tall, erect, and of a firm step; of grave manner in more formal relations, but always simple in tastes, a lover of intelligent society and of truthful, unaffected men; he enjoyed meeting with children, who returned his affection. He

loved the arts, especially music, and he delighted in outdoor walks, above all among the mountains. "He could hardly be called popular, for he neither flattered nor would receive flattery, nor had he the light and airy arts of familiarity which are sometimes mistaken for sincere goodwill. Yet he drew others to himself in a strong personal attachment." To his intimate friends he was a genial and lovable companion. To this fine end he reached when death came peacefully at his summer residence in Vallombrosa on July 23, 1882. He was buried in the Protestant cemetery at Rome on October 17 of that year. The following tribute was written at that time by W. J. Stillman:

"Those of us who have lived in the East, especially on the basin of the eastern Mediterranean, during the last twenty years, will have heard more, and measured better, the personality of the late George P. Marsh than his countrymen at home. His public services are matter of public record. Those who have access to his dispatches to the Department of State can tell better than I how he constantly studied whatever might be turned to the advantage of his country, and perhaps may read between the lines what he never made ostentation of, his love for it—an ardent, never-faltering, watchful devotion such as few public men have ever given their native land and few governments have acknowledged and recompensed as ours. An Englishman, Mr. Marsh had been a peer, and long ago in the enjoyment of a pensioned leisure to follow up the studies in which he was the most widely distinguished American. * * * It has been my fortune in a varied and adventurous life to make the acquaintance of many distinguished men, and of all I ever knew George P. Marsh was the noblest combination, *me judice,* of the noblest qualities which distinguish man—inflexible honesty, public and private; the most intelligent and purest patriotism; ideality of the highest as to his service in his official career; generosity and self-sacrifice in his personal relations; quick and liberal appreciation of all good in others, and the most singular modesty in all that concerned himself; unfaltering adherence to truth at any cost; an adamantine recognition of duty which knew no deflection from personal motive; and, binding the whole in the noblest and truest of lives, a sincere religious temperament, in which the extreme of liberality to others was united to the profoundest humility as to

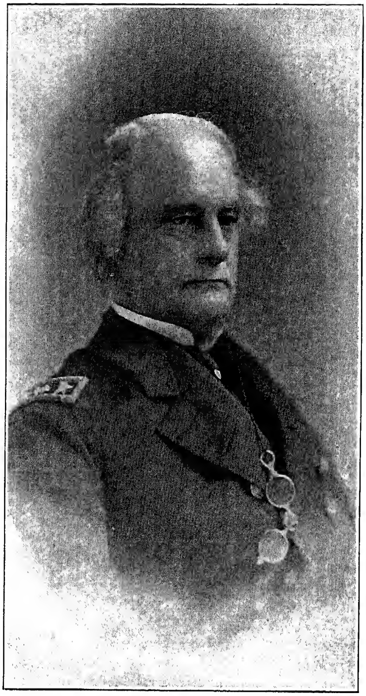
himself. * * * I knew no European who had met him who had not a higher esteem of our country from having known him. I have often heard European men of letters speak of him as a splendid result of American institutions, which perhaps in one sense he was. * * * He loved children, the Alps, the glaciers, the woods and fields and trees, with an untiring devotion, and the only complaint I remember his making of his own losses and decay was of his being unable to climb as he used to do." (The Nation, October 12, 1882.)

It was during his absence in Italy that Marsh was elected a member of the National Academy in 1866, and assigned to the Section of Anthropology and Philology. There is no record of his ever having presented a paper at any of our sessions. He was also a member of the American Philosophical Society of Philadelphia, an associate fellow of the American Academy of Arts and Sciences of Boston, a corresponding member of the American Geographical Society of New York, a foreign member of the Reale Accademia dei Lincei of Rome, and an honorary member of the Societá geográfica italiana. His large and rich library was after his death bought by Mr. Frederick Billings and given to the University of Vermont, at Marsh's old home in Burlington; his collection of engravings was bought by the Government and is preserved in the Congressional Library.

While Marsh was in Italy he finished and published his most noted scientific work, "Man and Nature, or Physical Geography as Modified by Human Action" (New York, 1865), afterwards revised as "The Earth as Modified by Human Action, a new edition of Man and Nature" (New York, 1874). Letters to Baird show that the book was begun at Burlington in 1860. The first mention of it is the following brief statement: "I began another book this morning and wrote 11 pages. I won't tell you what the book is about, because you'll call me names." The next letter said: "Well, I will tell you about the book. * * * It's a little volume showing that whereas Ritter and Guyot think that the earth made man, man in fact made the earth. * * * I am not going into the scientifics, but into the historicals, in which I am as good as any of you. * * * My father had a piece of thick woodland where the ground was always damp. Well, sir, he cleared up that lot, and drained and cultivated it, and it became a

good deal drier, and he raised good corn and grain on it. Now, I am going to state this as a *fact,* and I defy all you speculators about cause and effect to deny it." The book gained great popularity from its intrinsic value and interest. It brought together a wealth of knowledge on geographical and historical matters and presented them in a most attractive way. It treated debatable problems, such as the influence of deforestation on rainfall, with much better judgment than was the habit of the time, for although addressed to a large circle of readers it had genuine scientific spirit and thoroughness. It has certainly been rarely the case that a man who advanced a subject so far in a single book should leave that book as practically his only work of the kind.

In reviewing the life of this eminent man, who studied languages while he practiced law, who divided his time between business and politics, who wrote books and delivered lectures on literary subjects, and who investigated geographical problems while he elevated diplomacy, one cannot fail to be impressed with the breadth of his interests and the variety of his activities and duties on the one hand, and on the other hand the high degree of specialization and the necessary narrowing of interests and activities which has characterized the general membership of the National Academy. When we recall that the Academy was created to act as the scientific adviser of the Government—to examine and report upon any subject of science or art—one can hardly fail to question whether advice on the treatment of national scientific problems can be as well given by intensive specialists of the modern school as by men of a wider experience, of whom Marsh was so admirable an example.



Very truly yours

John Rodgers

BIOGRAPHICAL MEMOIR

OF

JOHN RODGERS.

1812-1882.

BY

ASAPH HALL

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL 18, 1906.

BIOGRAPHICAL MEMOIR OF JOHN RODGERS.

Rear Admiral JOHN RODGERS was one of the original members of the National Academy of Sciences. At the time of the organization of the Academy he was fifty-one years old and had acquired a reputation as a navigator, explorer, and surveyor.

John Rodgers was born August 8, 1812, at his mother's home, Sion Hill, near Havre de Grace, Maryland. He came from a family that had distinguished itself in our wars for independence. This family sent forth soldiers and sailors to serve our country in times of need, and it is well to recall some of its history in order to see the stuff of which our forefathers were made.

The immigrant, John Rodgers, came from Glasgow, Scotland, about 1750, and settled in Harford County, Maryland, where he became the owner of a large farm. His wife was Eliza Reynolds, of Delaware. This John Rodgers served in the Revolutionary War and was colonel of a regiment in the Maryland line. He was a highly esteemed citizen of Harford County. In the family of the immigrant there were eight children, all of them remarkable for physical strength and good looks. The oldest son, the second John Rodgers, ran away to sea, entered the navy, and was distinguished in the War of 1812. He became the senior officer of the navy, and died in 1837. A younger brother, George Rodgers, also entered the navy and died a commodore.

The wife of the second John Rodgers was Minerva Denison, of Havre de Grace. Her father, Gideon Denison, came from Connecticut, where he was noted as an Indian fighter. Denison was a land speculator and bought a large tract of land near the mouth of the Susquehanna River, where it was thought the capitol of the country would be located. This estate included Sion Hill, five miles from Havre de Grace, which became the home of the Rodgers family.

John Rodgers and his wife Minerva had eleven children, of whom ten grew up. Rear Admiral John Rodgers was the fourth child. The oldest brother, Robert Rodgers, served in the Civil War as colonel of a Maryland regiment. Two other brothers,

Frederick and Henry, lost their lives in the naval service. The youngest and only surviving brother, Augustus F. Rodgers, is the head of the U. S. Coast Survey in California.

In November, 1857, Rear Admiral John Rodgers married Ann Elizabeth Hodge, daughter of William Ledyard Hodge, of Philadelphia, and granddaughter of Andrew Bayard, of that city. This marriage was a happy one. Three children were born—a son, now Commander William Ledyard Rodgers, U. S. Navy, and two daughters, Frederica, now Mrs. Robert Giles, and Miss Helen Rodgers.

John Rodgers entered the navy as a midshipman in 1828, when in his sixteenth year. He served three and a half years at sea, in the Mediterranean and on home stations. After a short rest from sea duty he entered the Naval School at Norfolk, Virginia, where he spent a year. He then entered the University of Virginia for more general study, and spent a year in that university. He was then ordered to sea, and was employed three years on the South American station.

From 1839 to 1842 Rodgers was engaged in the survey of the coast of Florida and in fighting the Seminole Indians. His robust constitution carried him through this tedious work without loss of health. After a short period of duty on shore, Rodgers served three years in the Mediterranean and on the coast of Africa.

In 1849 he was again ordered to duty on the Coast Survey, and returned to the coast of Florida. There his vessel was wrecked and badly damaged, but by persevering work in beaching and caulking, the vessel was brought into Key West, a distance of over 300 miles. It was while lying at Key West in command of a small schooner of one gun, the *Petrel,* that Rodgers prevented the capture of the Cuban insurgent, Lopez, who was pursued by the *Pizarro,* a Spanish sloop-of-war.

The surveys and charts of the coast of Florida have been of great service.

In 1852 Rodgers was ordered to duty on the North Pacific Exploring and Surveying Expedition, and was placed in command of the steamer *John Hancock.* The squadron, in command of Commander Ringgold, left Hampton Roads in June, 1853, for the Indian Ocean. Several months were occupied in

surveying some of the islands southeast of Asia, the squadron arriving at Hongkong in May, 1854. Here Commander Ringgold was obliged to give up the command, on account of ill health, and Rodgers succeeded him.

The squadron proceeded to the survey of the Bonin Islands, south of Japan, and afterwards to the coast of Japan. In crossing the China Sea a vessel of the squadron, the *Porpoise,* with all hands, was lost in a typhoon. Search was made for the missing vessel, but nothing could be found.

It was in the *Vincennes,* under the command of Rodgers, that Lieutenant John M. Brooke first applied his apparatus for deep-sea sounding, from which such valuable results were obtained.

At the end of June the squadron sailed northward to Kamchatka and made a survey of the Sea of Okhotsk. At Glassenappe, an Indian village, 65° north, 172° 35′ west, a house was built, and Lieutenant Brooke and party were left on shore to make observations and exploration. The *Vincennes* then went northward through Bering Strait. It was Rodgers' intention to verify the discovery of land in 72° north and 175° west, reported by natives and former explorers, and which had been placed on the sea charts. The ship went to 72° 5′ north and 174° 37′ west, which was farther than any previous explorer had reached. No land could be seen from the yards of the ship and the water was clear of ice. Rodgers returned to Herald Island and exploring parties were landed. The position of the southeast point of the island was found to be 71° 21′ north and 175° 20′ west. No land could be seen from this island with a clear horizon. The ice pack appeared the next day and the party was compelled to turn back without having seen Wrangel Land, though within ten miles of its supposed position. A week was spent in surveys about Bering Strait, and on the 6th of September Glassenappe was reached. Lieutenant Brooke and his party were taken on board, and the *Vincennes* proceeded to San Francisco, where she arrived October 13, 1855.

After a short rest the *Vincennes* put to sea for surveying and deep-sea explorations. The month of March was employed in surveying the harbor of Hilo, in the Sandwich Islands, and the adjacent coast. The month of April was spent in the Society Islands, in surveying the harbor of Papiete, in the island Tahiti.

On the 29th of April Rodgers started for home around Cape Horn. After a voyage of seventy-four days, during which no land was seen, the vessel reached New York, July 12, 1856. During his absence Rodgers had been commissioned a Commander.

On August 30 Commander Rodgers was ordered to duty in Washington to superintend the reduction of his observations. His surveys in the North Pacific made an epoch in our knowledge of those regions. Nearly forty sea charts were based on these surveys, which have been very useful to navigators.

The Exploring Expedition was provided with a naturalist, a botanist, an artist, and a draughtsman, and instructions and suggestions were given by scientific men and societies. A good deal of information of the fauna and flora of the regions traversed was obtained, but the reports were never published.

The cruise in the Arctic Ocean at the middle of August, in a sailing vessel, in unknown seas, and amid fogs, was a daring exploit.

At the outbreak of the Civil War Rodgers was sent to Cincinnati to prepare a gunboat fleet to operate in the western rivers. In conjunction with General McClellan, three steamers were bought, altered, and armed. Commodore Foote took command of the fleet, and on October 17, 1861, Rodgers was ordered to command the steamer *Flag* on our southern coast. To join his command he sailed as a passenger in the *Wabash*, Admiral Dupont's flagship, in the expedition against Port Royal. In the battle of November 7 Rodgers volunteered to act on the staff of the commander-in-chief. Of his services in that engagement Admiral Dupont says:

"It would be difficult for me to enumerate the duties he performed, they were so numerous and various; and he brought to them all an invincible energy and the highest order of professional knowledge and merit. I was glad to show my appreciation of his great service by allowing him the honor to hoist the first American flag on the rebellious soil of South Carolina."

In command of the steamer *Flag* and some gunboats, Rodgers was employed in surveying the channels at the mouth of the Savannah River, and in removing torpedoes and obstructions, in coöperation with the land forces. In March he was recalled, and in April was appointed to command the *Galena*, one of the new

ironclads. In May, with the *Galena*, the *Monitor*, and three wooden vessels, he was sent up the James River to open a passage to Richmond. At Drury's Bluff barriers had been placed across the river, which were protected by Fort Darling and fortifications on the banks. With the *Galena* and the *Monitor* Rodgers engaged the batteries, and the firing lasted three hours, or as long as the ammunition held out. The fire from the fort was very severe and well directed, and the passage could not be carried without the aid of land forces. The *Galena* proved not to be shot-proof; thirteen shot and shell penetrated her side, and many men were killed by splinters of her own iron.

Rodgers was promoted Captain in July, 1862, and in November was ordered to take command of the *Weehawken*, one of the new monitors. On her first cruise out of New York the *Weehawken* encountered a severe gale, and doubts were entertained of her ability to keep the sea. But Rodgers refused to put into a refuge near at hand, saying that he was there to test the sea-going qualities of the new class of vessels.

In the attack on Fort Sumter, April 7, 1863, Rodgers, in the *Weehawken*, was selected by Admiral Dupont to head the line. This vessel remained under the fire of the batteries two hours, when the signal was given to withdraw from action. The *Weehawken* was struck fifty-three times and many of the vessels were disabled.

On the 17th of June following the engagement occurred between the *Weehawken* and the *Atlanta* near the mouth of the Savannah River. The *Atlanta* was formerly an English steamer, and had been covered with four inches of armor and armed with two six-inch and two seven-inch rifles. The *Weehawken* fired five shots, four of which struck the *Atlanta*. The first shot that struck the *Atlanta* put more than forty of her men out of the fight. The loss of men and the injury on the *Atlanta* were so great that she surrendered. For this victory and for his conduct in the war Secretary Welles recommended that Rodgers be promoted to the rank of commodore, and that he be given the thanks of Congress. In his letter the Secretary said:

"Your early connection with the Mississippi flotilla, and your participation in the projection and construction of the first ironclads on the western waters; your heroic conduct in the attack

on Drury's Bluff; the high moral courage that led you to put to sea in the *Weehawken* upon the approach of a violent storm, in order to test the sea-going qualities of these new craft, at the time when a safe anchorage was close under your lee; the brave and daring manner in which you, with your associates, pressed the ironclads under the concentrated fire of the batteries in Charleston harbor, and there tested and proved the endurance and resisting power of these vessels; and your crowning successful achievement in the capture of the *Fingal,* alias *Atlanta,* are all proofs of a skill and courage and devotion to the country and the cause of the Union, regardless of self, that cannot be permitted to pass unrewarded. To your heroic daring and persistent moral courage, beyond that of any other individual, is the country indebted for the development, under trying and varied circumstances on the ocean, under enormous batteries on land, and in successful rencontre with a formidable floating antagonist, of the capabilities and qualities of attack and resistance of the Monitor class of vessels and their heavy armament. For these heroic and serviceable acts I have presented your name to the President, requesting him to recommend that Congress give you a vote of thanks, in order that you may be advanced to the grade of Commodore in the American Navy."

In the fall of 1863 Rodgers suffered a few months of illness, but in November he was in command of the *Dictator.*

At the close of the Civil War Rodgers was placed in command of the squadron to which the *Monadnock* was attached in her experimental voyage to San Francisco. On arriving at Valparaiso it was found that hostilities were in progress between Spain and the South American republics. The city was threatened with a bombardment by the Spanish admiral, and Rodgers took a cautious but firm part in protecting American interests. Of his conduct Secretary Welles said:

"The department had taken measures for reinforcing our squadron in the Pacific by sending thither a special force, consisting of the turreted ironclad *Monadnock* and the steamers *Vanderbilt, Tuscarora* and *Powhatan,* under the command of Commodore John Rodgers. This officer reached Valparaiso previous to the bombardment of that city and, apprehending the views of the department, remained on the station for the pro-

tection of our countrymen until the arrival of Rear Admiral Pearson. The appearance of so distinguished a commander, with a formidable squadron, on the eve of so important an occasion, and in the absence of Rear Admiral Pearson, was opportune and fortunate.

The course pursued by Commodore Rodgers in protecting American interests, in observing and preserving neutrality in the harbor, met with approval. Whatever may have been his opinions or feelings as regards the course which the Spanish admiral thought proper to pursue, he was not required to interpose his force against or for either party. As the armed representative of this government, which was on friendly terms with each of the belligerents, it became his duty, even while endeavoring to mitigate the harsh severities of war, to maintain a strict neutrality. His friendly offices in the cause of humanity were manifested so long as they could be effective; but the officers of other neutral powers having declined to unite in any decided steps to protect the city, no alternative remained for him to pursue, consistently with the position of his government towards the parties, than that which he adopted."

Secretary Folger says:

"But the tact with which he maintained amicable and even friendly relations with Chilians, Spanish, English, and French, at the same time the firmness and persistence with which he presented the requirements of humanity enforced by the text of international law; the calm courage with which he approached the very verge of an appeal to arms, and the prudence with which he kept within the requirements of neutrality, remain yet to be fully written; but enough of his methods have become known to add to his previous reputation, that of being an able negotiator and diplomatist. His efforts for the protection of American interests on this occasion, while observing and preserving neutrality in the harbor, met with the hearty approval of his government."

From 1866 to 1869 Rodgers was in command of the Boston Navy Yard.

In December, 1869, he was made rear admiral.

Early in 1870 he was ordered to the command of the Asiatic squadron. It had been decided that a treaty should be made

with Corea, if possible, which should prevent the outrage of American seamen shipwrecked on that coast. Admiral Rodgers went to Corea in the spring of 1871 with a squadron of five ships and with Mr. Low, our minister to China. The Coreans were treacherous, and fired on our boats from their forts. A force was landed and the five forts were taken and destroyed.

On his return in 1872 Rodgers was appointed President of the Naval Examining and Retiring Board. In June, 1873, he was appointed to command the Navy Yard at Mare Island, where he remained four years, when he was appointed Superintendent of the Naval Observatory. The Naval Observatory was built on Camp Hill, near the Potomac River, in 1844. It was an unfortunate site for an astronomical observatory on account of the malaria that prevailed there and which attacked those who performed duty at night. After a use of thirty years the buildings and grounds were in need of repair. At first Admiral Rodgers had plans and estimates made for a complete renovation of the buildings and grounds. The estimated cost was so great that it was thought best to seek a new site and build a new observatory in a better location. After a thorough examination of the country around Washington, in which Admiral Rodgers took an active part, the Barber place of 70 acres, on Georgetown Heights, was chosen, and bought in 1880.

Admiral Rodgers urged the immediate building of the new observatory, and a board was appointed to consider the advisability of doing so. This board consisted of President Barnard, of Columbia University, chairman, and six associates of the Academy. Some of the scientific men in Washington opposed the change. They said the old site was healthful, and that it was a mistake to move out of the city. The board called for information on this question from medical men, and the report of Dr. John S. Billings settled the matter. The board recommended the building of a new observatory. The building was begun under Secretary Whitney, by Captain Phythian, in 1888, and was finished in 1893. Richard M. Hunt, of New York, was the architect. After a delay of eight years, the plans of Admiral Rodgers were thus brought to completion, though he was no longer living.

An important work of Admiral Rodgers in connection with the Naval Observatory should be mentioned. The library of the observatory needed enriching with rare books. He obtained from Congress an appropriation of $1,000 a year, and this has made the library one of the best astronomical and mathematical libraries in the country.

As Admiral Rodgers grew old his reputation and ability brought him many duties. These he performed faithfully, and his great physical strength enabled him to do a great amount of work. Probably he undertook too much. Besides being Superintendent of the Naval Observatory, he was President of the Transit of Venus Commission, of the Naval Advisory Board, of the Jeanette Relief Board, and chairman of the Light-house Board. Secretary Folger, of the Treasury Department, says of his services on the Light-house Board:

"The board has received valuable aid from his sage advice and his constant counsel. Notwithstanding his great age and consequent infirmities, and pressure of his many duties, the Admiral has visited many light-stations, and has personally superintended and taken part in numerous experiments, many in acoustics and optics, conducted on the sea or in the laboratory, and has so impressed his individuality on the service that his name will live with it, and add luster to his repute in the future."

The Admiral was taken ill in the winter of 1881-'82, and the disease soon assumed a fatal character. He was removed to the Barber house, on the site of the new observatory, and died there May 5, 1882, at the age of seventy years.

I am indebted to the memoir of Professor J. Russell Soley, U. S. N., for the outline of the professional services of Admiral Rodgers.

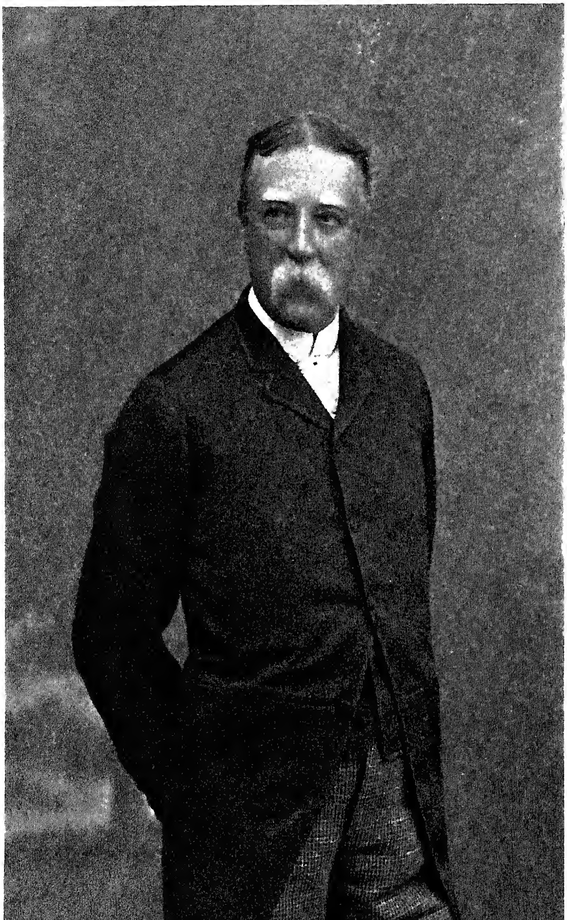
It was my good fortune to become acquainted with Admiral Rodgers in 1877, when he became Superintendent of the Naval Observatory. My first contact with him was rude. He came near taking off my official head, because of a complaint presented to him that I had not done my duty. He was a man of action, but he said, "We will wait a day or two," and in this time the accusation proved to be false. This led to a more intimate acquaintance. I found the Admiral one of the grandest men I have ever known. His character was open, frank, and noble. He

went straight forward in the path of duty perfectly fearless. He was ready to hear opposing argument with patience—in fact, rather liked it—and made up his mind fairly.

During the Admiral's fifty-four years of service, there is a record of only a few months of illness, and very little time was taken for rest and recuperation. Here was a genial, happy life, filled with the performance of duty.

After the storms and dangers of exploration and war, the Admiral passed away peacefully.

MARCH 15, 1906.



Fairman Rogers

BIOGRAPHICAL MEMOIR

OF

FAIRMAN ROGERS.

1833–1900.

BY

EDGAR F. SMITH.

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
NOVEMBER 22, 1906.

BIOGRAPHICAL MEMOIR OF FAIRMAN ROGERS.

It was some time in the 70s, while strolling through the halls of the University of Pennsylvania, that the writer was presented to the subject of this sketch. The brief conversation which ensued served to impress him with the fact that FAIRMAN ROGERS combined in himself not only the qualities of an attractive gentleman, but that he was also the possessor of faculties which made him the easy master of many of the most difficult problems which had arisen or which might arise in that domain of applied science to which he gave many of the best years of his life. Indeed, the impression made in that brief moment was that Fairman Rogers was constantly seeking to give to everything attracting his attention most earnest consideration. Nothing was so trivial but that, to his mind, it might be applied to useful purposes. The impressions received then were but strengthened by the representations made of the man by those who had known him intimately from boyhood, into and through manhood. That he was versatile will be obvious to any one who will take the pains to study his accessible publications.

We are informed that before he entered upon his college career, when perhaps fourteen or fifteen years of age, he was called upon by the head master of his preparatory school to address his schoolmates upon the telegraph. This he did, illustrating his lecture by means of wires attached to the walls and ceiling of the schoolroom. It is not surprising, therefore, that this intensely earnest and capable lad should afterwards have devoted himself to some of the most difficult problems in engineering science.

It seems to be conceded that Fairman Rogers inherited his scientific inclinations from his father, Mr. Evans Rogers, an iron merchant; though perhaps they may have come down to him from his mother, Caroline Augusta, the daughter of Mr. Gideon Fairman, a noted inventor, to whom he probably owed those social charms for which he was so noted and which were so characteristic of his maternal grandfather.

As a boy we are told that Fairman Rogers was admired and loved by all who knew him. He was "an adept in riding, dancing, swimming, skating," and all the things which go to make up a well-rounded boy life, yet never failed to do his duty in connection with the studies of his youthful period. After completing his preparatory years he was admitted to the college department of the University of Pennsylvania in 1849, when in his sixteenth year, as he was born on November 15, 1833, in Philadelphia. As a college student he ranked high, his favorite studies being mathematics and the physical sciences, though there is no doubt that because of his close and intimate relationship with Dr. John F. Frazer, who then taught the classes in physics and chemistry, he was given an opportunity to indulge his preferences for such subjects to a greater extent than most of the young men of that period. Dr. Frazer saw in his pupil great promise, and took every opportunity to bring him in contact with the leading men of science. It was at the home of Dr. Frazer that Fairman Rogers first made the acquaintance of the elder Agassiz, who was at once attracted by the earnestness, keenness, and extraordinary ability of the young man. It was in this home, too, that he learned to know other eminent scientists, and in this way his predilection for scientific subjects was fostered and developed.

His college career must have been truly one of great happiness and profit to him, and it is not at all surprising that in the short space of two years after his graduation, in 1853, we find him again in real, active scientific work as an engineer, under that able, inspiring, and genial Superintendent of the United States Coast Survey, Alexander Dallas Bache, who continued a friend of Fairman Rogers throughout his entire life, and with whom in 1857, as a volunteer, he assisted in determining the Epping base line in Maine. It was not only in field work that he was active at this time, but he was also engaged in delivering lectures on civil engineering subjects to classes at the University of Pennsylvania, where he had been installed as professor of that branch. In addition, he lectured upon mechanics, including physics, in the Franklin Institute.

In January, 1856, occurred his marriage to Miss Rebecca H. Gilpin, and "forty-four full years of mutual devotion hallowed a union whereof the world affords only too few examples."

Among the publications during his period of professorial activity is one entitled "Lectures on the Construction of Roads and Bridges." These were delivered in the Smithsonian Institution, at Washington, in 1861. They consisted in an examination of the principles which govern the location and construction of roads and of bridges.

He said:

"It would hardly seem necessary to dilate upon the immense advantages which spring from ample and economical means of communication throughout a country. In this age of rapid locomotion they are strongly set forth in the prospectus of every new railroad project and are familiar to all; but, somewhat strangely, while we have covered our country with these iron ways we have the doubtful honor of having the very worst common roads of any civilized country on the globe."

In another lecture we find him saying:

"In a new and sparsely settled country the road should be quite narrow, since then it is much more easily kept in repair. * * * Near large cities roads should have a width of from fifty to sixty feet, or even more. The surface must be such as will remain smooth and not be easily affected by the weather. * * * Drainage is one of the first objects of the engineer. * * * Every precaution must be taken to carry off the water which falls upon the surface. * * * The preparation of a road-bed to receive a coating of broken stones has been the subject of discussion between two eminent road-makers in England—Telford and McAdam; and opinion is still divided between the two systems proposed by them, although that of the latter, having the advantage of less first cost, has been most generally adopted. Telford, the engineer of the Holyhead road, thought that the stones should be laid upon a rigid foundation, and he therefore paved his road-bed with thin stones set on edge and laid the covering on that, considering that the stones would not in that case be forced out of place into a yielding surface below. McAdam, on the contrary, contended that the road covering thus placed between the wheels and the unyielding pavement would be rapidly ground to pieces, and that an elastic substratum is necessary to prevent such action. He consequently laid his road covering upon the natural

soil. * * * A difficult engineering problem has always been to find a good material for city streets."

At this rather distant day the ordinary layman reading these lectures becomes intensely interested. They undoubtedly were planned with the idea of making much-needed improvements, and they are presented in such an attractive and simple form that a non-technical person can comprehend and grasp all the important points. The illustrations accompanying these lectures are extremely simple and lend greatly to a clear understanding of them. One feels that they were written by an earnest student of engineering science. It was during this period also that Professor Rogers was chosen to lecture at Harvard University.

In 1861 he served as first sergeant of the first troop of the Philadelphia city cavalry in its three months' campaign. When mustered out he returned to his lectures at the Franklin Institute and to his classes at the University. It was about this time that he delivered a course of lectures on "Glaciers," at the Smithsonian Institution, in Washington, and made a survey of the Potomac for the United States Coast and Geodetic Survey. In the fall of that year he enlisted as a volunteer engineer officer with the Pennsylvania militia and took part in the campaigns of Antietam and Gettysburg. At the close of the war he was chosen captain of the first troop of Philadelphia's city cavalry.

In 1863 the National Academy of Sciences was instituted by Congress. Professor Rogers was one of the fifty original members and became the Treasurer of the Academy, serving in that capacity for a number of years, as well as upon its council and upon various committees. As it was one of the functions of the Academy to conduct investigations for the United States Government, Professor Rogers was requested to make a study of the compasses of the iron vessels then in the service of the government. They were sent to the navy yard at Philadelphia for his convenience, and there the work was carried on in a most able, conscientious, and satisfactory manner. This investigation led him to prepare a treatise on "The Magnetism of Iron Vessels." It was published later as one of the van Nostrand Science Series.

"It does not contain any material hitherto unpublished, but it is intended to give to an officer previously unacquainted with the subject sufficient information to enable him to undertake a series

of observations which would be of value in adding to the general knowledge of the subject, or in studying his own ship so as to avoid mishaps from a too firm reliance upon uncorrected compasses or from unexpected changes in new magnetic latitudes. * * * The treatise is offered to those engaged in navigation, especially to yachtsmen and scientific travelers, as a simple introduction to the subject and a guide in such observations as they might feel disposed to undertake."

Here again is further evidence of the fact that Professor Rogers' efforts, no matter what form they took, were inspired with the idea of extending the confines of human knowledge. The lectures upon road-making, to which reference has been made, and the little volume from which the prefatory sentences have been quoted show each, here and there, this praiseworthy object. This is observed again in the concluding lines of the little book on "Magnetism," for they read: "Every officer commanding or on board an iron vessel may add his share to perfecting the general knowledge of the subject by well-devised and carefully executed experiments and observations."

Truly the incentive to research and the application of scientific principles to the betterment of mankind, which were undoubtedly instilled into the mind of Professor Rogers by his teachers and friends, Frazer and Bache, remained constantly with him and cropped out at all times in his work, whether of a private nature or of a public character.

The catalogue of the University of Pennsylvania for the year 1871 bears the name of Fairman Rogers for the last time as a teacher in that institution. It was now transferred to the page upon which appear the names of the trustees of that venerable university, where for nine years it shone forth as an indication that in the conduct of the affairs of the university it was the purpose of its guardians to entrust the same to men worthy and capable.

In 1881, when the revered Dr. Charles Janeway Stillé laid down the duties of the office of provost of the university, Professor Rogers was earnestly requested to take up the work of Dr. Stillé, but for reasons best known to himself he declined the honor. It was shortly after this that he severed his connection finally with the university. But he was not idle. He became

deeply interested in the Academy of Fine Arts, and in 1881 published a most readable and interesting article on that institution, in which article occur words like these:

"It is necessary to bear in mind distinctly that these schools are supported in the interest of those who intend to become professional artists, that is, persons who expect to devote themselves to the production of pictures and statuary. * * * Those who, like lithographers, china painters and decorators, need nearly the same kind of education for their pursuits, are cordially welcome, and amateurs are at liberty to make what use of the school they can as far as its means and space permit. * * * With a very limited amount of money to spend, the effort is being made to carry on a school which in principle at least shall compare fairly with the best of those abroad. It must be left for the public to decide, upon the merits of its graduates, how far its promises are fulfilled in the future."

At this time Professor Rogers was chairman of the Committee on Instruction. He served the Academy for a period of twelve years. Under his direction its system was wholly reorganized, so that it attained the highest rank in this country.

Among the publications of Professor Rogers lying before the writer is a pamphlet on "Horsemanship." The instructions set forth in this pamphlet cannot fail to be read even today by any one interested in the horse with the intensest interest and sympathy. In the words of its author,

"Horsemanship had been and with most persons is still an art. Some men are born to be horsemen, as others are born to be musicians. * * * It is as impossible to make, by any course of teaching, a rider of a man whose body and mind are not suited to it as it is to make a musician of a man without an ear, although one may with perseverance be taught to sit upon a quiet horse and the other to play a simple strain. This difference existing in men, it is of some importance if the horse is to be ridden for general purposes, military or civil, that horsemanship should be reduced to a *science* as far as possible; or, in other words, that fixed rules, based upon correct principles, should be established, which will enable the instructor to teach and the pupil to understand up to a certain point, beyond which the rider's own genius must be depended upon."

Again we have, in these few words, the effort of our colleague to introduce system into pleasure as well as into a utilitarian practice. He proceeds:

"It is absurd to suppose that while by properly directed practice a man may increase the strength of certain muscles and the flexibility of certain joints, the horse cannot be improved mechanically in the same manner. There are many horsemen who seem to think that a well-made, active horse ought to do without previous education everything that any horse can do as soon as he can be made to understand the will of his rider. As well might we expect any active, well-formed young woman, without practice and yet with the strongest will, after having witnessed one hundred representations, to perform the movements of an Ellsler or a Cerito."

It was in this way that he introduced or called attention to the great system of training for horses as proposed by Baucher. "For," he adds,

"Baucher insists upon gentleness, kindness, patience, and appeals to the understanding of the animal in all stages of training, coupled with courage and decision, for indecision is sometimes most provoking to an animal with which we cannot communicate directly by means of language; in other words, the trainer must have a clear idea himself of what he wishes to do and must not change his mind just as the operation commences, or he will worry his horse, or, as Baucher says, 'shock his understanding.' The horse should be made to understand that the man can by some power combat his most vigorous exertions and conquer him. This 'breaking' was performed by 'rough riders,' who by harsh and sometimes brutal treatment reduced the horse to a state of subjection; but happily there is no longer any excuse for any brute who may thus treat the animal destined to serve man's pleasure, for there are methods, based upon true principles, by which the horse, however wild and savage, finds himself without pain or injury inflicted upon him, suddenly and in the most mysterious manner, completely in the power of his weak master, and sooner or later gives up with a good grace and with his power and spirit unimpaired. Thus subdued, he must next be taught the power of the bit and saddle, and must go through a course of gymnastics to enable him to do what his rider requires. When a

horse runs at liberty in the field his step is springy and free, depending in degree, of course, somewhat upon his natural conformation, and if he is ordinarily well formed his muscular forces are exerted in such a way as to keep his body in a condition of equilibrium. All this comes naturally to him as walking does to a child; but when we place upon his back a weight equal to one-sixth of his own and expect him still to be as graceful and as easy as when

"'Free he roamed the grassy wild,'

we are expecting rather too much of him. If any one doubts this, let him put thirty-five pounds in a knapsack or take a child pick-a-back and attempt to execute gracefully a walk, a dance, or a bow. He will find a noticeable change in the position of his center of gravity and a decided sense of heaviness on his legs, the effect of which it will take a considerable amount of loaded drill to overcome. * * * Baucher commences his instruction with a simple lesson. Standing in front of the horse, he taps him on the chest with the whip, keeping up the light blows as long as the horse retreats from them, instantly ceasing the taps and caressing him when he comes forward; and in a short time the horse, finding that to avoid the punishment he must move forward and not backward, advances upon the slightest touch; and the first method of communication is thus set up with him. Then, since the communication between the hand of the man and the mouth of the horse is by means of the bit, attention must next be paid to its action. The horse has two ways of resisting the pressure upon the bit—by closing his mouth and holding his jaw rigidly fixed, and by extending his head and neck into as nearly a straight line as possible, either by throwing both down or by throwing both up. The first of these is overcome by the flexions of the jaw. The jaw being flexed, the neck must be attended to, and by the proper pressures on the bit the horse is made to understand that he finds relief when he holds his neck well up and his head in a vertical position, that in which in reality he can oppose the least resistance to the hand of the rider. By these flexions we not only teach the horse to do a certain thing, but the exercise enables him to do it, the muscles which sustain the neck being strengthened and the neck rendered more flexible, especially near the head,

where the new curvature of the neck may be distinctly seen when, as horsemen say, the neck is broken. The flexions of the neck are not painful to the horse, but they are somewhat fatiguing, as is a new exercise or a new position to a gymnast, and they must therefore be practiced with judgment so as not to disgust the animal with the operation. Having thus educated the head and the neck of the horse, the other parts of the body are attended to, and thus the mechanical resistances are overcome which interfere with the movements that the animal is required to make. The use of the whip and the use of the spur receive careful attention, and it will be observed that the gaits of the horse are improved. They become more springy, and the balance upon the feet such that the movements of the rider are more readily communicated to him."

Throughout the entire communication from which these quotations and paraphrases have been made the spirit of scientific interest is maintained, and the concluding words are:

"If riding is indulged in as a pastime, let it be carried to the highest point of perfection; if it is a necessity, as in military service, let all know how to do it in as comfortable and agreeable a manner as possible, and neglect no means to attain this desirable end."

The last contribution of Fairman Rogers was his "Manual on Coaching." This he prepared after devoting a number of years to the subject in a practical way. It is a volume of almost 600 pages, and in it there is evident everywhere the desire of the author to introduce scientific principles. Thus, in chapter IX, after speaking of the weight of the coach, the author continues:

"We now come to one of the divisions of our subject important from a practical point of view—the position of the center of gravity of the coach. The center of gravity of a body is that part in which its whole weight may be considered as concentrated; in a symmetrical body of equal thickness and equal density in all its parts it is at the center of the figure of the body. For example, a square piece of board of even thickness will have its center of gravity at the point at which its two diagonals cross. If at that point we bore a hole and hang the board on a smooth pin the board will remain in any position into which we turn it, because

the center of suspension and the center of gravity coincide. If we suspend it from some other point we will find that the board will hang steadily in one position only, namely, when the center of gravity is vertically under the point of suspension. If we flatten one corner slightly we can make the board stand upon it, but it will be in unstable equilibrium, and will fall to the right or to the left at the slightest touch. We therefore say that the board is in equilibrium when the center of gravity is vertically above the point of support. Conversely, the center of gravity is above the point of support when the body is in equilibrium. Now, a coach looked at from behind is symmetrical as to the distribution of its parts about its vertical center line, and its center of gravity must be therefore somewhere in that center line. If we tip the coach on the two wheels of one side until it exactly balances and would fall to either side, the center of gravity must be in a vertical line passing through the point of support, and since it is always in the center line of the coach it must be at the intersection of these two lines. We can determine by this experiment the angle at which the coach will tip over, or, what is the same thing, the elevation of the wheels of the higher side which will cause it to balance. * * * If from going fast over a bad road or from the horses galloping unevenly the coach gets to swinging laterally, the higher the center of gravity the more readily will the coach turn over, since it is obvious that a horizontal force applied to the coach near the top will pull it over more readily than the same force applied nearer the ground. The danger in turning the corner is increased by a high center of gravity. A body in motion has, by reason of its inertia, a tendency to continue its motion in the original direction until it is acted upon by some exterior force. A coach going along a straight road is deflected when it comes to a corner by the horses pulling it around the turn. It has, however, a tendency to keep on in a straight line, and this tendency is shown as a force acting at right angles to the direction of the coach, pulling it outward from the circle in which it is moving. This is called the centrifugal force. * * * This force varies exactly with the weight. * * * With a known weight of coach the centrifugal force corresponding to any speed round a turn of any

radius may be computed. The formula for this computation is as follows:

$$\text{"centrifugal force} = \frac{w v^2}{32.2 r},$$

where w = weight in pounds; v = velocity in feet per second; and r = radius of curve in feet, etc."

And in another chapter the author gives a mathematical demonstration of the amount of power (draught) required to overcome a resistance to the motion of the vehicle from two points of view—first, the actual mechanical force expended, and, second, the way in which that force should be applied by an animal. The question of axle friction, ball bearings, the effect of grades, etc., are duly considered. The paragraphs relating to the action of a horse in draught, his attachment to the traces, etc., also receive careful thought. There seems not to be one point that is not touched upon by the author in this admirable publication. To produce the evidence of this statement would require more space than we can justly give to this contribution. A few paragraphs, however, may be here introduced. Thus:

"A coachman should sit straight and square to the front, his shoulders back and his knees and feet close together, his toes not projecting beyond the edge of the footboard. It is hardly necessary to add that he should never cross his legs or have one foot in advance of the other. If he sits with his feet drawn back, off of their proper place on the footboard, he is simply preparing himself to be thrown on his wheelers' backs in case of striking a stone or post. The whip is held by the right hand at the ferrule, and at an angle of 45° from the horizontal and 45° to the front. In this position the thong is above the one-wheeler, and the whole whip is out of the way of a person on the box. If it is near to this passenger a sudden touch of a branch in passing will drive the whip back into his face before the coachman can stop it. If it is too low the loop of the thong may touch or catch on passing vehicles."

This final work of Fairman Rogers must be regarded as a classic in its domain, and, as the writer has repeatedly said, it shows how the mind of its author was constantly turned to his

special subject of engineering and introducing science into everything in which he was interested.

Some years ago numerous and most interesting experiments were carried out at the University of Pennsylvania by Professor Muybridge upon the photography of animals in motion. It is believed that the principle employed by Muybridge was suggested by Professor Rogers. Similar adaptations of this principle, which is that of the zoötrope, are also found in the biograph and the cinematograph.

Photography claimed the attention of Professor Rogers forty-five years ago, and it is mentioned by his friends that one of the very first typewriters, perhaps the first, was set up in his library by the inventor, and there is every reason to believe that the attention Professor Rogers gave this instrument led to suggestions in the way of improvement and betterment that were gladly received by the inventor.

Professor Rogers loved flowers, pictures, and books most passionately. Books in his specialty of civil engineering he collected in great numbers. . They were most complete. They constitute a part of the library of the University of Pennsylvania today, as does his remarkable collection of works on horsemanship.

The Union League, a club of Philadelphia favorably known all over the country, had Professor Rogers as one of its founders. He was also a member of various riding and hunting clubs, of the American Society of Civil Engineers, and of the American Philosophical Society. He was indeed a many-sided man, and after giving up his engagements in this country and going to Europe for a rest, his mind remained active. He could not be idle, and it was then that the "Manual on Coaching" was written. The book was evidently most kindly and heartily received. The volume which the writer has had the pleasure of examining was drawn from a public library, and shows that it must have been in frequent and constant use since its deposition there. How fortunate it is that the author lived long enough to enjoy this recognition of his labors. Five years ago, at Vienna, on August 22, 1900, the spirit of Fairman Rogers was called hence, and in the language of the scholarly Dr. Horace Howard Furness, who knew him long and well—

"A choicer spirit has seldom visited this earth. To a k intellect were united clearness of exposition and a retentive m ory. Warm and loyal in his friendships, he never cherished ill feeling, for no one ever did him an unkindness. On m an institution of his native city an ineffaceable impression been left of his judicious devotion; of unstinted hospitality the most considerate and attentive of hosts; of such exqui urbanity that although emphatic and inflexible in his mat convictions, he was never known to give offense in express them; of high veracity and a delicate sense of honor, and of s imperturbable serenity that it may be said with absolute tr that a harsh or hasty word never fell from his lips.

"Possibly it may be thought by those who did not know l face to face that in what has just been said there is too muc the 'personal equation.' Be it so. We were children toget boys together, men together, brothers in love and in law. I but say what I believe."

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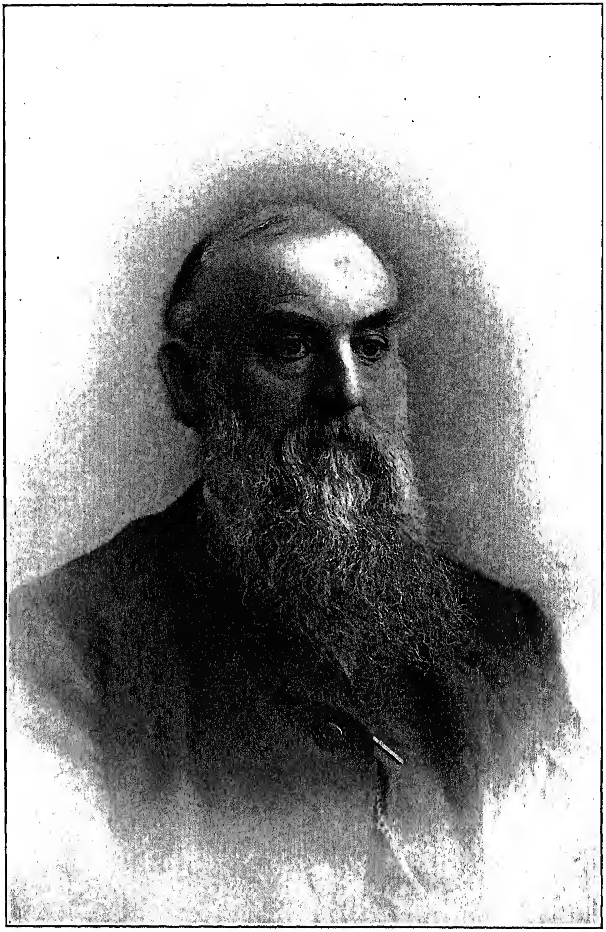

As ever yours
W A K

BIOGRAPHICAL MEMOIR

OF

WILLIAM A. ROGERS.

PART II.

ASTRONOMICAL WORK.

BY

ARTHUR SEARLE.

BIOGRAPHICAL MEMOIR OF WILLIAM A. ROGERS.*

During the years in which Professor Rogers was connected with Alfred University his duties as a teacher and the limitations of his instrumental resources prevented him from making extensive astronomical investigations. So far as circumstances permitted, however, he made himself an active astronomer. He frequently computed the orbits of asteroids and made an interesting series of observations, necessarily attended by much personal discomfort, on the possible variations of personal equation resulting from fatigue or hunger. During the time which he passed at Harvard College Observatory on leave of absence from Alfred University he made a determination of the latitude of the observatory with a transit instrument in the prime vertical.

On returning to Harvard College Observatory as an assistant, in 1870, he was assigned to duty with the new meridian circle as soon as that instrument was mounted, and shortly afterwards he took exclusive charge of it, which continued until his removal to Colby University, in 1886. His work with this instrument included, first, the observation of 8,627 stars between the parallels of declination (for 1855) at 49° 50′ and 55° 10′; secondly, numerous observations of other, and generally brighter, stars, undertaken in connection with the zone observations just mentioned; and, thirdly, the observation, during the years 1879 to 1883, inclusive, of a special list of stars the right ascensions and declinations of which were to be determined independently of all previous observations. This required the very frequent observation of transits of the Sun and of Polaris.

The first of these three kinds of work was undertaken as a part of a comprehensive scheme formed by the Astronomische Gesellschaft for the accurate observation of the places of all stars not fainter than the ninth magnitude. Its results are published in the Annals of the Observatory of Harvard College, the fifteenth

* Part I Biographical Memoir of William A. Rogers, by Edward W. Morley, may be found in volume IV, pages 185–199.

volume of which comprises a catalogue of 1,213 stars, including those used as fundamental in the zone observations, while the second part of the same volume is occupied with the catalogue of the 8,627 stars of the zone itself. Volume XVI of the same series contains the separate observations of the stars used as fundamental and others observed in connection with them, partial publication of which had previously been made in volumes X and XII. Volume XXV contains the comparison of the separate observations of the zone stars with each other, and of their mean results with those previously obtained elsewhere. Finally, volumes XXXV and XXXVI contain the journals of the zone observations.

Professor Rogers lived to see the completion of all these volumes, the preparation of which remained under his charge after his removal to Colby University. They comprise the results of the first two classes of work which he carried on with the meridian circle. The work of the third class, that relating to the independent determinations of right ascension and declination, was only partially prepared for publication at the time of his death. Its reduction is still in progress. The work itself demanded extraordinary exertion on his part, as it required observations to be made at irregular and constantly varying times, which might occur at any hour of the day or night.

Besides the larger publications above mentioned, Professor Rogers frequently furnished the results attained from time to time in the progress of his work for publication in the astronomical periodicals and the proceedings of learned societies. As minor investigations of an astronomical nature which he undertook may be mentioned determinations of differences of longitude between Harvard College Observatory and other places, and observations for personal equation in the use of the meridian circle and of Mr. Chandler's instrument called the almucantar and described in volume XVII of the Annals of the Observatory.

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Vol. x. Observations made with the Meridian Circle. 1871–1872. (239 pp.)

Vol. xv. Catalogue of 1,213 Stars observed at the Astronomical Observatory of Harvard College, with the Meridian Circle, during the Years 1870 to 1879. (174 pp.)

Vol. xvi. Observations of Fundamental Stars made with Meridian Circle. 1870–1886. (337 pp.)

Vol. xxv. Part i. Discussion of Proper Motions of Zone Stars, 1879–1883 (382 pp.)

Vol. xxv, Part ii. Catalog der Astronomische Gesellschaft. Catalogue of 8,627 Stars between 49° 50′ and 50° 10′ of North Declination. For the Epoch 1875. (176 pp.)

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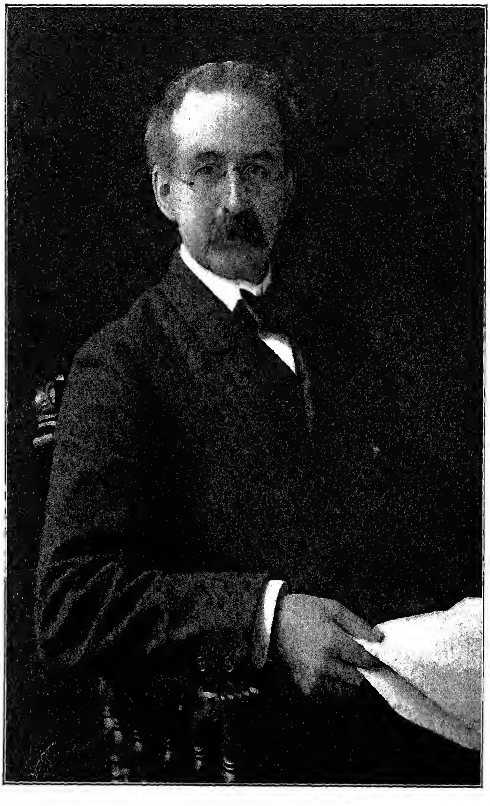

S. L. Penfield

BIOGRAPHICAL MEMOIR

OF

SAMUEL LEWIS PENFIELD.

1856–1906.

BY

HORACE L. WELLS.

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL 18, 1907.

BIOGRAPHICAL MEMOIR OF SAMUEL LEWIS PENFIELD.

The subject of this memoir came of a prominent family and was born in Catskill, New York, January 16, 1856, spending his boyhood in that beautifully situated village on the banks of the Hudson. His father, George H. Penfield, a highly esteemed and useful man in his community, was a shipping merchant, as had been his father before him. The mother of our mineralogist, Ann Augusta Cheeseman, was a native of Stratford, Connecticut. She was a woman of strong character and rare culture, and it is interesting to know that members of her family have displayed much mechanical ingenuity.

There is a record of seven generations of Penfields in America before our scientist. The emigrant, William, was born in Wales in 1650 and settled in Massachusetts. The succeeding ancestors lived in Wallingford, Connecticut, and then in Fairfield, in the same state, until the grandfather, Samuel L. Penfield, as a young man, removed to Catskill. Penfield possessed, as a cherished family heirloom, a portrait in oil of his great-great-grandfather, Samuel Penfield of Fairfield. This picture shows an evidently prosperous gentleman in the costume of the Revolutionary period, and with strong, interesting features. Another of his valued possessions was the Yale diploma of the next Samuel Penfield, his great-grandfather, who was graduated in 1783, and became a lawyer, residing in Fairfield.

Penfield's early home was one of refinement, cheerfulness, and great hospitality. He received from his parents an inheritance and a training which gave him high ideals and made him the upright, absolutely honest man that he was. As a boy he was active, fond of long walks among the mountains near his home, an expert swimmer, and a skilled oarsman. Never particularly strong or athletic, he was so energetic and possessed such endurance that all his life he was able to accomplish an astonishing amount of work. The youthful trait which probably had the most significance in regard to his future career was his unusual skill in the use of tools. This, together with his general

mechanical ability, enabled him, apparently without instruction and with little practice, to produce remarkable pieces of handiwork. In his youth he built a beautiful bookcase which adorned his library to the end of his life, and during the same early period he made a light cedar rowboat, a fine specimen of boat-building, which he used for years in taking exercise upon the Hudson.

It is not known that the future mineralogist showed any marked precocity in his earlier studies, but he graduated with honor at the Catskill Academy, and then went to the academy at Wilbraham, Massachusetts, to prepare for college. From the time when he was a small boy he had desired to go to Yale, but there is no doubt that his interest in science, leading to his selection of the Sheffield Scientific School, was awakened during his course at Wilbraham. In after years he often spoke of having received excellent instruction in physics there, and of having taken much interest in that course of study. It would be a pleasure to acknowledge here this service of the Wilbraham teacher, but his name is not known with certainty.

Penfield appeared in New Haven as a freshman in the autumn of 1873. He was a handsome young man, rather slender, somewhat above the average height, with black, slightly curling hair, and a rather dark, rosy complexion. He was a quiet, but sociable person, with pleasing manners and a happy disposition. It was my good fortune to be his classmate, to take exactly the same course of study in our undergraduate career, and afterwards to be his room-mate and intimate companion for many years. This long acquaintance and close intimacy revealed no flaw in his fine character and led to ever-increasing admiration of him.

He was a most conscientious student, a diligent and faithful worker. He did not attract immediate attention for ability, however, for he had little facility in reciting, while subjects requiring mere memory, particularly languages, were difficult for him. It may be mentioned in this connection that he improved remarkably in fluency of expression as years went by, and that he showed much aptitude in acquiring the German language a few years later, when it was presented to him practically in its own country. In contrast to the difficulties just mentioned, it

became evident very early in his college course that he was acquiring a more thorough understanding of mathematical and scientific subjects than most of his apparently more brilliant companions. Besides this, he did excellent work in the free-hand and mechanical drawing of freshman year, as was to be expected of one with his natural manual skill.

Upon taking up the study of analytical chemistry and determinative mineralogy during the next year, he astonished his fellow-students by the ability and deftness which he displayed in these practical lines of work. His skill with his hands was such that he was from the outset a master in chemical manipulation and in the use of all kinds of scientific apparatus. During this year he had an attack of typhoid fever which interrupted his studies for many weeks. Most men, under the circumstances, would have dropped back into the next class, but he not only made up the large amount of work that he had missed, but actually took the prize in determinative mineralogy for that year.

The course just mentioned was Penfield's first introduction to the science in whose service he afterwards labored so long and successfully. The beauty of crystallized minerals at once appealed to him strongly, as did also the ingenious tests by blow-pipe and the other means for identifying them. Although at that time he had no intention of becoming a mineralogist, he began to develop the wonderful skill that he afterwards displayed in recognizing minerals at sight. It is much to the credit of Professor George J. Brush and his assistant, the late Dr. George W. Hawes, that they aroused in Penfield such an interest in mineralogy.

During the third and last year of his undergraduate course, Penfield's success in chemical laboratory work was even greater. He soon finished the prescribed work of the course, at that time confined almost entirely to inorganic analysis, and took up more advanced investigations. As a subject for his graduation thesis he undertook a study of the basic sulphates of copper obtained by precipitation. This subject was not of his own selection, and the amorphous precipitates were found to be variable mixtures of little interest, so that the results were never published; but he made a great number of preparations and

analyzed them with such rapidity and skill that his work must have been a revelation to some of his instructors. He then took up the analysis of minerals, and among other things analyzed triphylite from Grafton, New Hampshire. This phosphate, containing iron, manganese, calcium, lithium, and sodium, presented analytical difficulties which had not been surmounted, as it appeared later, by several chemists who had published analyses of it. It might have been expected that so young and inexperienced a chemist would have been unable to solve this problem, but there were several circumstances in his favor. The first was that of his personal qualifications of manipulative skill and enthusiasm. Another favorable condition was that of the excellent traditions and practice of analytical chemistry in the Sheffield laboratory, due to the instruction and example of Professors Brush, Brewer, Johnson, Mixter, and Allen, all of whom had studied chemistry abroad and counted among their teachers such masters as Liebig, Bunsen, and Plattner. Finally, in making this analysis, Penfield had the benefit of the direct advice of Professor Allen, a man of rare judgment in the selection of analytical methods. As a result, this was the first good analysis ever made of triphylite, indicating a much simpler formula than the one previously accepted. This was the beginning of Penfield's important work in simplifying the formulas of minerals by means of accurate analyses of pure material, and it led to the publication of his first scientific paper.

Penfield was graduated with honors in 1877. He had studied his books faithfully and much of the time had worked in the chemical laboratory almost constantly from morning until night; but, being of a very companionable disposition, he had nevertheless found time to make many close friendships among his fellow-students.

The first three years after his graduation formed a most important period in Penfield's scientific development. Two of these years he spent as assistant in the chemical laboratory, the third as assistant in mineralogy. It was the writer's privilege to return as a graduate student, to be Penfield's room-mate during these three years, and to work beside him in the laboratory during much of this time.

We were now able to work at night in the laboratory, which was so small in those days that Professor Allen frequently worked in the same room with us. His chemical sagacity has been previously mentioned, and it was fortunate indeed that he was most generous in discussing chemical matters and giving valuable advice, particularly during those evening hours. Penfield was exceedingly quick at acquiring knowledge in a conversational way, but, being essentially an experimentalist, he was not much inclined to gain information by reading; hence there is no doubt that Professor Allen's influence upon his development was a very important one.

A most fortunate circumstance, during the first year of Penfield's graduate study, was the bringing to light of the Branchville mineral locality by Professors Brush and E. S. Dana. These gentlemen labored most enthusiastically in developing it, and soon several new phosphates and other interesting species, new and old, were disclosed. Penfield took up the chemical examination of the new phosphates, eosphorite, triploidite, and dickinsonite, and soon analyzed them with masterly skill and precision. Sharp ratios and beautifully simple formulas resulted from these analyses, except in the case of dickinsonite, where the material could not be obtained in a pure condition. Mr. F. P. Dewey and the writer also worked on Branchville phosphates at this time, but their work was not as extensive as that of Penfield. As far as the writer is concerned, he was conscious of being but a poor imitator of Penfield's skill and rapidity, and it was only by working all night on one occasion that he finished an analysis more quickly than his gifted friend had done a similar one.

Those difficult phosphate analyses were wonderfully beneficial to the group of young chemists, led by Penfield, advised by Professor Allen, and encouraged by Professor Brush. Experience led to improvements in methods and greater facility and rapidity in applying them, so that the difficulties rapidly disappeared.

The next year, 1878-79, Penfield analyzed several triphylites, and by his remarkably beautiful results placed beyond question the simple formula now accepted for that mineral. He analyzed also the new Branchville phosphates, fairfieldite and fillowite, as well as samples of chabazite and rhodocrosite from the same

locality. In that same remarkably productive year, while also attending faithfully to his duties as laboratory assistant, he turned out a masterpiece in the shape of eight analyses of amblygonite, from various localities, which gave a new and simple formula for that mineral, under the assumption previously put forward by Brush and Dana that fluorine and hydroxyl play the same part in minerals. This view was based on Penfield's analysis of triploidite, a compound containing hydroxyl, which was observed to have the same form as triplite and wagnerite, analogous fluorine compounds. In his work on amblygonite, Penfield showed that fluorine and hydroxyl replace each other in the same mineral—a generalization which was destined to play an important part in his future work in simplifying mineral formulas. The publication of this work on amblygonite brought down upon him the wrath of the great German authority, Rammelsberg, who characterized the hydroxyl-fluorine idea as "unchemical," and remarked that the analysis of amblygonite was no theme for beginners. From Rammelsberg's point of view, this was indeed a difficult problem; but our beginner was already a past master in mineral analysis, and, besides, he was in a position to employ methods far superior to those previously used in the examination of such phosphates; so that he solved the problem where his critic, the great authority of much experience, had failed. The hydroxyl-fluorine idea prevailed in spite of Rammelsberg's attack upon it, and it is interesting to relate that Penfield visited Rammelsberg many years later, when the latter was near the end of his long life, and was most cordially received by his predecessor in mineralogical fame. No allusion to past differences was made in that memorable interview, although it appears that Rammelsberg never accepted the hydroxyl-fluorine theory.

In connection with his amblygonite analyses, Penfield incidentally devised a new volumetric method for the determination of fluorine, which has been extensively commended and employed since its publication.

The following year, as usual, he did many things in addition to his work of instruction, which was now carried on in the mineralogical laboratory. He made a most skillful examination

of childrenite, using less than a gram of material for this complicated analysis and obtaining duplicate determinations upon most of the constituents. He showed that its composition was analogous to that of the eosphorite which he had previously analyzed, as was to be expected from the similarity in form of the two minerals. It appeared that Rammelsberg, as well as another chemist, had failed to find a large part of the alumina in childrenite, and had thus arrived at an incorrect formula.

In mentioning some of Rammelsberg's analytical failures here it is not intended to give discredit to the reputation of that celebrated mineralogist, who made a vast number of excellent analyses; but such mention seems to be necessary in order to emphasize the difficulty and importance of Penfield's work.

This same year Penfield analyzed three samples of manganiferous apatite, and also did a very important piece of work in the chemical examination, for Brush and Dana, of spodumene and its alteration products from the Branchville locality. This investigation included an analysis of unaltered spodumene, three analyses of the mixture called β-spodumene, an elaborate chemical examination of this mixture, which led to the discovery of the new mineral eucryptite as one of its constituents, and two analyses of the mixture called cymatolite, which led to a satisfactory explanation of its composition as a mixture of albite and muscovite. In connection with the same investigation, he also made analyses of specimens of muscovite, microcline, and killinite. The high character of this series of silicate analyses was shown by the sharpness of the ratios, the simplicity of the formulas, and the importance of the deductions that Brush and Dana were enabled to draw from them in regard to the two puzzling microscopic mixtures.

It would not appear that even a wonderful analyst could have done any further work that same year, but during that time he did a large amount of technical work in analyzing cereals, in connection with some Government work under the direction of Professor William H. Brewer. This was done with the purpose of furnishing means for studying in Germany, which he was planning to do at the end of the college year. The cereal analyses being arranged for at a fixed price for each, Penfield

set up his apparatus and turned out the work with such speed and skill as were simply astonishing to the writer, who was doing similar work in the same building—South Sheffield Hall—for the Connecticut Agricultural Experiment Station. In this connection it may be mentioned that in after years Penfield made it a principle to refuse outside technical work, in order that he might devote his spare time wholly to his scientific investigations. This course involved much self-denial on his part, because at times the demands upon his purse were large in proportion to his salary.

At the end of three years of postgraduate work, when only twenty-four years of age, Penfield was a truly great analytical chemist, and had turned out an astonishing amount of fine work. In future years he was destined to produce much more work of this kind, and to broaden his experience with methods, but he had already come so near perfection in the management of analyses that there was little room for future improvement in the quality of his investigations. Difficult analyses always appeared to attract rather than to discourage him. He had perfect confidence in himself, was full of enthusiasm, and anxious to arrive quickly at his results; but at the same time he was exceedingly conscientious about his work, and this strict honesty led him to examine his methods and test his results so carefully that he never made poor analyses. Accidents and failures, so common with most analysts, were very rare in his case, on account of his manipulative skill and good judgment. It was a pleasure and an education to see him work, and to observe his neatness, deftness, and orderly arrangements. He enjoyed the work greatly, too, and often said that making an analysis was one of his chief pleasures. The writer of these lines owes very much to the privilege of having worked beside him and having had such an example to follow.

In the spring of 1880 Penfield went to Germany for further study. After residing for some time in Hanover, in order to become more familiar with the language, he took up the study of organic chemistry under Fittig in Strassburg, and remained there for two semesters. From our present point of view, this course of study appears to have been unnecessary, as he after-

wards took little interest in the subject; but at that time it was his intention to make a career as a chemist, and organic chemistry was then a very prominent subject. However, while at Strassburg he heard some lectures by the mineralogist Groth and also took a course in experimental physics. He was much interested in the organic work, and afterwards was glad that he had taken it, as it gave him a broader education. It led to the publication of a paper in conjunction with Fittig upon an unsaturated organic acid and some of its salts.

Upon his return from Germany in 1881 Penfield accepted the instructorship in mineralogy in the Sheffield Scientific School, thus determining his future career, for he devoted the remaining twenty-five years of his life to that department. This return to mineralogy appears to have been a fortunate circumstance, for he was particularly well fitted for this work and had already become a leader in one branch of the subject. He soon took the entire charge of the instruction in mineralogy, as his predecessor, Professor Brush, was obliged to give up this work on account of his increasing duties as director of the school.

In order to fit himself more thoroughly for his mineralogical work, Penfield went to Germany again in 1884, and for one semester studied the optical properties of minerals and crystallography under Rosenbusch in Heidelberg. These studies he took up with much enthusiasm, for his natural aptitude in mathematics, his skill with instruments of precision, and his great interest in minerals made the work very congenial to him.

His mastery of physical mineralogy was as rapid and thorough as his development in chemistry had been, and from that time he followed both lines of investigation in an impartial manner, but with an increasing tendency toward crystallography. The fact that he covered so ably both the chemical and physical sides of mineralogy is particularly noteworthy, for other distinguished mineralogists have usually been prominent in only one of these directions. His ardent devotion to mineralogy was such that he was decidedly a specialist, but in that specialty he was broad.

Penfield became assistant professor of mineralogy in 1888, and was advanced to full professorship in 1893. His enthusiasm

and skill in mineralogical research never diminished, and he continued this work throughout his lifetime with remarkable industry.

After taking charge of the mineralogical department he often generously gave important chemical work to his advanced students, but this work was under his close personal supervision, and he frequently took part in it, so that its quality was similar to his own. His occasional work in coöperation with investigators outside of his university should also be mentioned. In these cases he usually took the crystallographic part, as was the case in his work with Professor Genth, of Philadelphia.

In all but his earliest chemical researches he made extensive and very effective use of heavy solutions in purifying his material for analysis. In many cases this was the only means of removing impurities and obtaining the minerals in a sufficiently pure condition, and, always desiring the greatest possible accuracy, he applied this method whenever it could be of assistance. He exhibited his usual remarkable dexterity in applying the various heavy solutions for this purpose, and in one instance he devised a special form of apparatus for the use of the fused mixture of thallium and silver nitrates.

We owe to Penfield, besides the volumetric method for the determination of fluorine, a number of other improvements in analytical methods, for it was his practice in many cases to study carefully the methods that he used by applying them to known mixtures, so that he arrived at a number of new inventions or important modifications. His work on the determination of water in minerals was one of the most noteworthy cases of this kind.

Besides his analyses, already mentioned, of six new minerals for Brush and Dana, Penfield described, sometimes in conjuction with other workers, no less than fifteen new minerals, a brief account of which will now be given.

Gerhardite (with H. L. Wells, 1885) is a basic nitrate of copper, in orthorhombic green crystals, and is the only nitrate insoluble in water known as a mineral.

Nesquehonite (with F. A. Genth, 1890) is an orthorhombic, hydrated magnesium carbonate, $MgCO_3.3H_2O$.

Spangolite (1890) is a hydrated sulphate and chloride of copper and aluminium remarkable for its composition and beautiful, hexagonal, green crystals.

Hamlinite (with W. E. Hidden, 1890) is a hydrous fluophosphate of aluminium, strontium, and barium, and is remarkable in being the only known natural phosphate containing barium or strontium.

Canfieldite (1894) is a sulphostannate of silver, containing also the exceedingly rare element germanium.

Pearceite (1896) is a sulpharsenate of silver, or arsenical polybasite.

Roeblingite (with H. W. Foote, 1897) is a complex silicate and sulphite of calcium and lead, the only known natural sulphite.

Bixbyite (with H. W. Foote, 1897) is a combination of iron and manganese oxides, essentially $FeMnO_3$.

Clinohedrite (with H. W. Foote, 1898) is a zinc calcium silicate of peculiar monoclinic habit.

Hancockite (with C. H. Warren, 1899) is a silicate related to epidote and piedmontite, but containing a considerable quantity of lead.

Glaucochroite (with C. H. Warren, 1899) is a silicate of calcium and manganese.

Nasonite (with C. H. Warren, 1899) is a tetragonal lead calcium silicate.

Lucophœnicite (with C. H. Warren, 1899) is a hydrous silicate of manganese.

Graftonite (1900) is a phosphate of iron, manganese, and calcium, which was curiously intergrown with triphylite.

Tychite (with G. S. Jamieson, 1905) is a carbonate and sulphate of magnesium and sodium. The actual mineral was analyzed only qualitatively, but the formula was determined from an artificial product crystallizing in the same form and containing the same things.

Even more important than his work with new minerals were Penfield's investigations upon the composition and form of species which were already known. New minerals could be studied only when they happened to be found, but there was

an abundance of old material at his disposal in the Brush collection, and, besides, interesting specimens of old minerals were frequently found by him or sent to him for examination.

Mention has already been made of Penfield's early work in establishing correct formulas for the minerals triphylite, amblygonite, and childrenite. In later years he performed the same service, often in collaboration with others, with some twenty other minerals, a list of which will now be given.

Monazite (1882, and with E. S. Sperry, 1888) was found to be an orthophosphate of cerium, lanthanum, and didymium with an admixture of thorium silicate.

Ralstonite (with D. N. Harper, 1886) was purified by means of a heavy solution and given a satisfactory formula upon the basis of the fluorine-hydroxyl idea.

Herderite (with D. N. Harper, 1886) was given the simple formula $CaBe(F,OH)PO_4$.

Howlite (with E. S. Sperry, 1887), a hydrous calcium borosilicate, was given the rank of a well-defined mineral species.

Connellite (1890), a hydrous, basic combination of the sulphate and chloride of copper, was given a satisfactory formula from a remarkable analysis made with only 0.074 grams of the exceedingly scarce material.

Aurichalcite (1891), a basic carbonate of zinc and copper, was given a simple formula.

Allurgite (1893), a member of the mica group, was given a reasonable formula.

Argyrodite (1893), the remarkable silver mineral in which the new element germanium was discovered, was shown to have a slightly different composition from that originally ascribed to it.

Cookeite (1893), a mica, was given a new formula.

Chondrodite, Humite, and *Clinohumite* (with W. T. H. Howe, 1894), a group of silicates to which simple formulas were given on the basis of the replacement of fluorine by hydroxyl. These formulas were shown to have a most interesting relation to the crystalline forms of the minerals, so that an unknown member of the series was predicted, both as to its composition and form. The Swedish mineralogist Sjögren soon afterwards found a

mineral with the predicted form, and not having enough of it for an analysis, ascribed it to the predicted composition and gave it the name prolectite, from προλέγειν, to fortell.

Staurolite (with J. H. Pratt, 1894), a very common silicate, was successfully purified and given a simple formula.

Topaz (with J. C. Minor, 1894) was shown to contain hydroxyl replacing fluorine, and was provided with a good formula, $(AlF)_2SiO_4$, in which F is replaceable by OH. Moreover, it was shown that the specific gravity and optical properties of the mineral vary with the percentage of flourine, so that the latter could afterwards be determined by a physical or optical examination.

Hanksite (1885, and J. H. Pratt, 1896) was found to possess a curious composition in being composed of sodium sulphate, sodium carbonate, and potassium chloride.

Ganomalite (with C. H. Warren, 1899) was shown to be probably analogous to Nasonite, with hydroxyl taking the place of the chlorine of the latter mineral.

Tourmaline (with H. W. Foote, 1899), a mineral whose complex composition had been much discussed, was given a plausible formula, based upon the idea that the mass effect of a large complex radical determines the crystallization and permits wide variations in the remainder of the molecule.

Sulphohalite (1900) was shown to be a compound of sodium sulphate, chloride, and fluoride, in which the flourine had been previously overlooked.

Turquois (1900) was given a satisfactory formula, and the occurrence of copper in this phosphate was explained.

Amphibole (with F. C. Stanley, posthumous, 1907) was explained on an assumption similar to that used in the case of tourmaline.

Besides giving the crystallography of the new minerals that he described, Penfield established the crystalline forms of *Amarantite, Argyrodite, Bertrandite, Herderite, Lansfordite, Metacinnabarite, Penfieldite, Polybasite, Sperrylite; Tiemannite, Willemite, Calaverite,* and *Stibiotantalite* (the last two with W. E. Ford), and he published numerous observations upon interesting developments or habits of the crystals of still other species.

Nor was his crystallographic work confined to minerals, for he was very generous in giving much time to the study of artificial crystals prepared by various chemists. For instance, he described the forms of a large number of double salts and other compounds prepared by the writer, and in that connection obtained some interesting results in relation to the effect of the replacement of one element by another. Much of his work upon artificial crystals is scattered through chemical literature and does not appear in the lists of his publications.

It should not be forgotten that Penfield's liberality in encouraging the independence of others led to the publication of a large amount of work from his laboratory which did not bear his name, although he acted in an advisory capacity. Thus J. H. Pratt described a new mineral, Pratt and H. W. Foote described another, while these and other assistants and advanced students published the results of many important investigations not bearing Penfield's name, although in most cases he suggested the work and carefully superintended it.

During the last few years of his life, Penfield became much interested in the application of graphical methods, in connection with stereographic projection, for the solution of crystallographic and other problems of spherical trigonometry. He published several articles on this subject and devised several pieces of ingenious apparatus for carrying out his methods, such as engraved circles and scales, as well as a series of protractors printed on transparent celluloid sheets. These methods have since been extensively employed by other crystallographers. He also advocated the use of his graphical methods for geographical maps and sailing charts, but apparently made little impression upon the conservatism of established usage in these directions.

Professor Penfield's scientific work may be summarized as comprising mineralogical investigations of great abundance, variety, accuracy, and importance. The thoroughness with which his pieces of work were carried out is also particularly striking. He was not satisfied until he had settled every possible point in regard to a mineral that he was studying. One of his notable achievements was the establishment of the replacement of fluorine

hydroxyl and the simplification of the formulas of many ierals upon this basis after making accurate analyses of them. other remarkable piece of work was his discovery of such itions between composition and form in a group of minerals t he was able to predict the existence of a mineral not yet :overed.

Iis scientific attainments have been widely recognized. He elected Fellow of the American Academy of Arts and ences in 1893, Foreign Correspondent of the Geological So- y of London in 1896, Member of the National Academy of ences in 1900, Fellow of the American Association for the rancement of Science, Corresponding Member of the Royal iety at Göttingen, and Member of the Scientific Society at istiania in 1902, Corresponding Member of the Geological So- y at Stockholm, and Foreign Member of the Mineralogical So- y of Great Britain in 1903, and in 1904 the University of Wis- sin conferred upon him the degree of Doctor of Laws.

'he result of nearly all of Penfield's researches were pub- ed in the "American Journal of Science." He brought to- ier many of his more important articles in one of the bicen- iial publications of Yale University issued in 1901, and in volume he gave also an interesting account of the develop- it of mineralogy at Yale, including a full bibliography.

'he teaching that Penfield did was a most important part iis life work, and although the results that he achieved in direction are less tangible than those of his researches, they probably of even greater consequence.

n taking charge of the mineralogical course of instruction he Sheffield Scientific School he inherited from his predeces- an excellent plan of teaching, the main feature of which always followed. The beginners were taught blow-piping the accompanying chemical and physical tests for minerals, were required to identify minerals in this way. Then the eral collection, brought together by Professor Brush with ı good judgment that it was an extraordinarily good one teaching purposes, was exhibited by means of lectures, and he same time the principles of crystallography were incul- d.

Penfield's continual effort was to make this course in mineralogy more instructive and interesting. With this end in view he improved the collection of unlabeled minerals by adding to it typical specimens, so that the students in using small fragments for their tests could observe the appearance of the minerals with which they were dealing. He installed also a labeled collection of the more important minerals, to which the students had free access, and thus could confirm their identifications by comparison and become familiar with a wider range of characteristic specimens. He arranged neat exhibits of specimens illustrating color, form, and other physical properties of minerals, and was particularly painstaking in supplying the laboratory and lecture-room with crystal models and other apparatus elucidating crystalline structure. Much of this apparatus he made or devised with great skill and ingenuity.

He gave much attention also to the improvement of laboratory instruction by preparing printed laboratory directions and other aids for students, and the results of much painstaking experience in the testing of minerals, including many devices of his own, were incorporated in the new edition of Brush's "Determinative Mineralogy," which he rewrote, enlarged, and published in 1898.

He was a successful lecturer in the class-room, but was at his best in laboratory instruction, where he came into contact with the students individually. In this work he was kindly, patient, persistent, and thorough. He was very appreciative of good work and progress on the part of the student. He was untiring in his devotion to his advanced students and never allowed his own investigations to interfere with giving them all possible advice and assistance. He inspired his co-workers with his own enthusiasm, and imparted to them much of his knowledge and skill. Among those who worked with him and have since followed scientific careers, in some cases in geology or chemistry, are Professors L. V. Pirsson, H. W. Foote, and W. E. Ford, of the Sheffield Scientific School; Professor J. H. Pratt, of the University of North Carolina; Dr. E. O. Hovey, of the American Museum of Natural History; Dr. O. H. Farrington, of the Field Columbian Museum, and Professor C. H. Warren, of the Massachusetts Institute of Technology. The

names of many others who made investigations with him will be found in the list of his publications.

The mineralogical laboratory, during Penfield's connection with it, was situated in the Yale Peabody Museum, where the Brush collection was also deposited until 1903, when the department was moved to a new building, Kirtland Hall, on the grounds of the Sheffield Scientific School. At the time of this removal Professor Brush made a gift of his whole collection to the school, together with a liberal endowment for its care and enlargement, and Penfield was appointed as its official curator. He had previously given much attention to the collection, both in assisting Professor Brush in its care and also in connection with using it in illustrating his lectures on descriptive mineralogy and crystallography, for which purpose he had beautifully mounted and arranged many of the specimens. He now undertook and fully carried out the arrangement of the collection in its new cases in the new building, and many excellent features of this great collection, as now arranged, are due to his unequalled taste and skill.

In Kirtland Hall, Penfield had also the pleasure of planning and putting into operation a model laboratory for instruction and investigation in all branches of his department of science. This was done with his usual good judgment and common sense, and this beautiful laboratory, containing so many of his inventions and such numerous examples of his orderly arrangements of apparatus and specimens, will long remain a fitting reminder of this great mineralogist.

The removal to Kirtland Hall was practically coincident with his failure in health, so that his enjoyment of it was much diminished. However, he went on bravely and cheerfully, working to the end.

Penfield's publications are noteworthy for their general clearness and conciseness. He used great care and much time in preparing his manuscripts, usually making several revisions of them before they satisfied him. In his younger days his scientific writing was something of a hardship to him, but with practice his facility in this direction improved remarkably. Professor Miers, of Oxford, mentions his clearness of exposition as ex-

hibited in the "Determinative Mineralogy" and says: "The introductory chapters which he wrote for this book are models of clear and lucid treatment, and among the very best that can be placed in the hands of elementary students."

Penfield was naturally very friendly and sociable, he attracted others by his many good qualities, and he made enduring friendships among his associates everywhere. A classmate who retained close intimacy with him throughout his after life is Professor J. P. Iddings, of Chicago, who recently pronounced a beautiful tribute to him before the Geological Society of America, in which he spoke of him as "A genial and loveable companion whose cheerfulness, generosity, steadfastness, and absolute honesty in thought and action form his most memorable characteristics." Another classmate and close friend is Col. Morris K. Belknap, of Louisville, Kentucky. This good friend has recently founded in his memory a "Penfield Prize" in mineralogy in the Sheffield Scientific School.

Penfield remained unmarried for twenty years after his graduation, and lived, usually with two or three companions, in the upper part of South Sheffield Hall, in apartments familiarly known as "The Attic." It was my good fortune to be one of those companions during nearly all of this time. Another long resident there was Professor L. V. Pirsson, who was for a time Penfield's pupil, then his assistant, and finally his colleague in the closely related subject of petrology. This intimate friend and associate has paid worthy tribute to Penfield in a biographical essay published in the "American Journal of Science." Another member of that coterie was the late Professor C. E. Beecher, the gifted and beloved geologist, whose loss, as well as Penfield's, this academy deplores, as one of its eminent members.

Much pleasure and profit came from the companionship of those days. Many interesting conferences took place in those quarters after the day's and evening's tasks were done, in which Penfield and the others discussed the progress of their work and often obtained advice and encouragement in regard to it.

The relations of Penfield and the writer in connection with their work were particularly close. The crystallographer was frequently called upon to display his unfailing kindness in

examining crops of crystals for the chemist, to see if they were pure, or to make some other application of his knowledge and skill. On the other hand, it sometimes happened that the chemist was able to help the mineralogist by advice in regard to analytical methods, for Penfield preferred actual work to the study of books, and it was well that he did, for thereby he accomplished much more in the direction in which he was so highly gifted.

Penfield did not confine himself unduly to his laboratory, although it happened that he worked evenings as well as in the daytime, when he was particularly interested. He took outdoor exercise with considerable regularity, and participated frequently in the social gatherings of his many friends in New Haven. He usually availed himself of the vacations for rest and recreation or for mineralogical excursions. Two summers he spent in the Yellowstone Park, as assistant to his friend Iddings, then connected with the United States Geological Survey. Other summer vacations he spent partly or wholly in collecting minerals and observing their occurrences in northern New York, Colorado, North Carolina, Maine, Nova Scotia, and still other localities. It was a great pleasure to be with him on such trips, for he was full of enthusiasm and a most agreeable companion. He spent the summers of 1894 and 1897 in Europe, visiting a number of fellow-mineralogists and looking at many collections in the course of his travels. His reception on both these occasions was exceedingly cordial. One of the results of those visits was a particularly firm friendship with Professor H. A. Miers, of Oxford University, who has written a most sympathetic biographical account of him. Another valued friendship thus formed was with our Foreign Associate, the Norwegian geologist, W. C. Brögger, who has recently dedicated one of his books to Penfield.

The beauty and simplicity of Penfield's character impressed all who knew him. He was generous, sympathetic, unselfish, and unassuming. He showed unlimited loyalty to his friends and was exceedingly lenient to their shortcomings or to any opinions that they might hold which differed from his own. His good deeds were many in helping the needy and suffering, and through-

out his life he retained, with complete unobtrusiveness, the simple religious faith that he had acquired in his childhood.

In January, 1897, he married Miss Grace Chapman, of Albany, New York, thus bringing much happiness to his few remaining years. In the delightful home which he then established he took much pleasure in entertaining his many friends, for hospitality was one of the strongest traits of his character.

Penfield was always conscientiously careful of his health, being regular in his habits and extremely temperate in his manner of living. It did not appear that he was sapping his strength by overwork, for he seemed vigorous and well; but he was suddenly attacked by that much-dreaded malady which interferes with the assimilation of saccharine substances. From this he suffered for more than three years, showing wonderful fortitude and patience under the restrictions imposed upon him. Eminent medical specialists did all in their power for him, while his colleagues, Professors Chittenden and Mendel, gave his case thorough scientific attention, and his wife gave him most devoted care. Under these circumstances and by his own obedience to the prescribed regimen, his life was undoubtedly prolonged; but all efforts were unavailing, and the end came, fortunately with little suffering, on August 12, 1906, at South Woodstock, Connecticut, where he was spending the summer. Until two days before his death he had been very happy and comfortable and had been cheerfully making plans for the future.

He rests in his native village, Catskill, which he loved so well. He is survived by his wife, a sister, and a brother.

The accompanying portrait is from a photograph taken about four years before his death.

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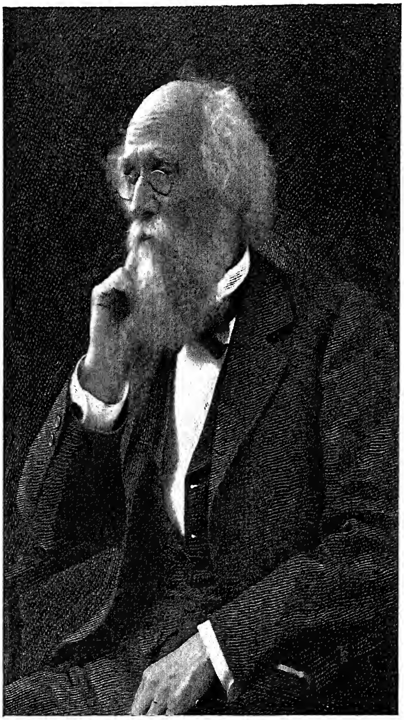

Jo. LeConte

BIOGRAPHICAL MEMOIR

OF

JOSEPH LE CONTE.

1823-1901.

BY

EUGENE W. HILGARD.

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL 18, 1907.

PREFATORY NOTE.

In writing the memoir of the life and scientific work of Dr. Joseph Le Conte, it has seemed to me proper and best to follow, so far as practicable, his autobiography, in which the facts, events, and motives are presented by himself in their proper connection and order, better than could be done by any one else. In the abridgment of his text I have purposely striven to retain in a great measure his own mode of diction and expression, considering it desirable that he should appear essentially in the light in which he viewed himself; and that the somewhat exceptional mode of mental growth of a man so highly gifted, under conditions now fast becoming extinct, should be succinctly put on record in connection with the discussion of his broad scientific work, to which is due the length of this paper. The writer's long-continued and close personal relations with the subject of this memoir have afforded some side-lights which do not so clearly appear in Le Conte's published writings, and it gives him pleasure to fulfill herewith a promise mutually made as to the service the survivor should render to his friend.

E. W. HILGARD.

BERKELEY, CALIFORNIA, *March*, 1907.

BIOGRAPHICAL MEMOIR OF JOSEPH LE CONTE.

DESCENT OF THE LE CONTE FAMILY.

The distinction achieved by several of the members of the Le Conte family renders it interesting to trace their origin as far back as possible, particularly in the interest of the question of the heredity of mental and intellectual traits.

Owing doubtless to the dissensions of the times during the persecution of the Huguenots under Louis XIV, Guillaume, the ancestor of the American Le Contes, adopted the name of his mother, of the house of the Barons de Nonant, in Normandy. His paternal name has not been traced by the family. There is a tradition that he was warned of impending danger by King Louis himself. He fled to Holland, from where he joined the great Stadholder, William of Orange, in the invasion of England. He subsequently also served with distinction in the English war for the conquest of Ireland, and in 1698 emigrated to America, whither two cousins of the Nonant line had preceded him. Like many other Huguenots, he settled at New Rochelle, New York, where at that time we find domiciled also another group of Le Contes or Le Comtes, apparently unrelated.

In 1701 Guillaume married Marguerite de Valleau, of Martinique. The report that he married twice appears to be unfounded. Both died of yellow fever in 1710. Three children were born of this marriage, viz., Guillaume, Pierre, and Esther, of whom the latter probably died in childhood. Guillaume the younger married Elise Anne Beslie, of New Rochelle, by whom he had one child, a daughter, from whom descended Mother Seton, the founder of the Sisters of Charity in this country, and the late Archbishop Bayley, of Baltimore.

The second son of Guillaume the elder, Dr. Pierre Le Conte, who lived in New Jersey, married twice. His second wife was Valeria Eatton (related to the Biddle, Baird, and Berrien

families), by whom he had five children—William, John Eatton, Margaret, Thomas, and Pierre. William became a lawyer and took a prominent part in the Revolutionary struggle in Georgia, whither he, as well as Thomas and Pierre the younger, had moved. The latter two never married.

John Eatton, from whom all subsequent Le Contes are descended, was born in 1739, and died in New Jersey in 1822. He spent his summers in New York and his winters on his plantation, "Woodmanston," in Liberty county, Georgia. Like his brother William, he was accounted a "malignant" and rebel. In 1776 he married Jane Sloane, of New York, by whom he had three sons. The eldest, William, died unmarried. Louis, born in 1782, went to Georgia and there married Anne Quarterman, who became the mother of John and of Joseph Le Conte, the subject of this sketch. John Eatton, the third son, became a major in the U. S. Corps of Topographical Engineers, and married Ann Lawrence, who became the mother of John L. Le Conte, the distinguished entomologist.

Louis, the father of Joseph Le Conte, born in New Jersey in 1782, was educated in New York, graduating at Columbia College when only seventeen years old. He studied medicine under Dr. Hosack for some time, but is not known to have graduated as a physician, his main object being probably to practice on his own plantation. He was, however, called "doctor."

Louis Le Conte was a remarkable man, and his influence on the characters and life pursuits of his sons was so great that *his* life and character must be briefly considered. He lived on the "Woodmanston" plantation in Liberty county, Georgia. The region had been settled by a community of English Puritans, who originally founded Dorchester, Massachusetts; they were very moral and somewhat clannish and exclusive, so that when Louis came among them he was considered an outsider; but eventually, after his marriage with one of the members of the exclusive set, the warmest mutual relations were established. He was greatly interested in scientific pursuits, especially chemistry and botany; and in the then unexplored field by which he was surrounded he identified the described species and discovered many new plants, but never named or published them, and

freely gave his material to his scientific friends. His beautiful garden became known all over the United States and brought many visitors, who were hospitably entertained. His botanical insight disliked the mechanical arrangement of the Linnean system, so that he always referred his plants to their natural relationships. He was also a skillful mathematician. Aside from these intellectual pursuits, he attended personally to the management of his large plantation, with 200 slaves, whom he regarded as a heavy responsibility and constantly strove to control by religious and moral instruction, for which special "praise-houses" were established in the community. The negroes were greatly attached to him and proud of calling him "master." He also exerted himself in behalf of the instruction and general betterment of the condition of the white "crackers" inhabiting the pine woods some distance away. Though not a member of any particular church, his benevolence and charity made him universally beloved and respected.

It was under these influences, to which was doubtless added the inheritance of their mother's highly artistic temperament, together with natural surroundings of great beauty and scientific interest, in which the children were free to roam at will, that their characters and temperaments were shaped.

The issue of Louis' marriage were four sons and three daughters, of whom one died in infancy. The other six children grew up to marry and have children of their own. The mother, however, died early (in 1826), so that her direct influence upon Joseph could have been but slight; but her death prostrated the father, who remained plunged in gloom for years, until by the marriage of the elder children, William and Jane, grandchildren came to dispel, in a measure, the cloud of sadness. But the intervening period of sorrow had greatly impressed its seriousness upon the children and influenced their temperaments.

BOYHOOD AND COLLEGE EDUCATION OF JOSEPH LE CONTE.

Joseph Le Conte was born February 26, 1823, being the fifth child and the youngest son. With his three brothers, of whom Lewis was the nearest to him in age, he was accustomed to range the woods, fields, and swamps of the region freely, in quest of game, fish, and specimens of natural history, upon which the

father then commented instructively. Joseph became a good marksman, fisherman, swimmer, and athlete; in the latter accomplishment he afterwards greatly excelled. Of necessity, playthings, marbles, bows and arrows, canoes, and even rudimentary firearms, were made by the boys themselves. Joseph's formal schooling was scanty, in a country school supported by a few families and which was constantly changing teachers; but among the latter there was for two years Alexander H. Stephens, subsequently United States Senator and Vice-President of the Southern Confederacy, with whom he maintained a lifelong friendship. His imagination was much excited by the tales told and accounts given by imported negroes, of things in their native land, and of border warfare in which they had participated.

His country schooling and boy life ended in December, 1838, when, as he was about to go to college at the age of not quite 16 years, his father died from accidental blood-poisoning, at the age of 55 years. This event, which he had always put away from himself as almost impossible, stunned and dazed him; but, in obedience to his father's expressed wishes, he left home a week afterward, with his brothers John and Lewis, for the college at Athens, Georgia, 300 miles away; he up to that time having never been more than eight miles away from home. It was a week's journey, mostly by stage, and brought him in contact with an unfamiliar world—not very attractive to him, for he suffered severely from nostalgia for several months. The temptations usually supposed to beset young students entering college seem to have been no temptations to him; all coarseness and vulgarity merely repelled him, and he simply and naturally kept away from them and their devotees. During the first year he received a letter from his eldest brother, William, a deeply religious man of the old orthodox type and his legal guardian. This letter "alluded with distress and doubt to their father's dying outside of the pale of any church" and vehemently urged upon Joseph the necessity of "fleeing from the wrath to come." This letter greatly distressed and impressed him, and at a religious "revival" he and his brothers, with many other students, joined the Presbyterian Church, although the church at Midway was of the Puritan-Congregationalist faith; but they concluded that the Presbyterian was "good enough" for them.

He refers to this as a great crisis in his life, having experienced a sudden, almost miraculous conversion, followed by great joy and relief. He says that "the change was a sense of the deliverance from the fear of death and the hereafter—not the establishment of a new relation, but the discovery of the true relation existing." But his elder brother's admonition that he might feel it his duty to become a minister of the gospel did not prevail, and he remarks that "one may be a preacher of righteousness in more ways than one."

Although a member of one of the college literary societies, he never became a good debater; but he greatly delighted in the society of refined women, and entertained toward women in general a romantic feeling, as toward superior beings, which he declares to be "the greatest of all safeguards for the purity of young men."

Le Conte does not attribute to himself any unusual diligence in study while in college; yet he was both a junior and senior orator, the titles of his addresses being "True Greatness" and "Love of Truth, the Highest Incentive to Effort." The manuscripts of these efforts he afterwards destroyed because dissatisfied with them. "The skillful putting together of commonplaces of literature into a brilliant patchwork" he states he could never do, and that "the ability to write anything of value came late," and not until he "had independent thoughts of his own."

During his college course at Athens the natural-history sciences were almost wholly neglected, these being but feebly represented in the faculty. Charles F. McCay seems to have impressed him as the only strong man in the faculty, he representing mathematics and physics.

Le Conte's college life was uneventful, not even accompanied by the usual "pranks." His vacations were passed at the old plantation or with his brother William, at Cedar Hill, where he renewed his old sports of hunting, fishing, &c. In January, 1841, that brother died—"the second great affliction I have suffered by death."

POSTGRADUATE STUDIES AND TRAVELS.

Le Conte and his brother Lewis graduated from the Athens College in August, 1841. Their sister Anne having graduated about the same time, the three agreed to make a tour of the Northern States. During this first excursion into the outer world, they visited first the city of Washington, with the magnificence of whose buildings and monuments they were greatly impressed, as also by the oratory of Webster, Calhoun, and Clay in Congress. After a week at the capital they visited Baltimore, Philadelphia, Boston, and Cambridge, returning via New York, where there was a family reunion, their married sister, Jane, and their brother John, lately married, gathering at the house of their uncle, John Eatton Le Conte, the father of John Lawrence, the entomologist, the latter then but sixteen years of age. Returning in November, all stayed during winter at Woodmanston plantation, with their sister Jane. On this occasion Joseph become acquainted with John T. Nisbet, the uncle of his future wife. Hunting, fishing, and excursions occupied their time. In spring and summer more extended excursions were made, from Macon and Athens into the mountains of Georgia. Thereafter Joseph began the study of medicine under Dr. Charles West, at Macon, until the beginning of winter, which he again passed at the old plantation, riding, hunting, and fishing in company with his cousin, John L., who had come on a visit which was greatly enjoyed by both.

About this time the great comet of 1843 appeared, and greatly impressed him. This summer he first met his future wife at the house of his friend Nisbet, but at that time he was not permanently impressed; in fact, another fair face held his attention just then.

Le Conte now determined to take up medical studies in New York, and attended the winter course (1843-1844) of four months at the College of Physicians and Surgeons. Among his instructors were Dr. Torrey and Dr. Lewis Sayre. He characterizes the course as a period of regular cram and hard work, such as, it will be noted, had not fallen to his lot during any of his previous rather care-free life.

It was doubtless the taste for outdoor and more or less physically strenuous life that led him to undertake, in company with his cousin, John L., an excursion to the then Far West, the headwaters of the Mississippi, via Niagara, Buffalo, Detroit, and the Great Lakes. This trip he considers as a very important phase in his development, as it attracted his attention permanently to the great geological features passing before him, and gave renewed and definite direction to his subsequent chief work. Hence some space must be given to its discussion.

His comments on the conditions then prevalent in what are now some of the chief centers of commercial and industrial activity are very interesting. Buffalo and Detroit were then small towns, with little indication of their future greatness; the University of Michigan was in its beginnings. At Detroit, where they passed a week in pleasant company, they were persuaded to visit the Lake Superior country, to which they proceeded by the regular steamer via Lakes Huron and Michigan, stopping at Fort Mackinac and at Chicago, then a budding city of 5,000 inhabitants. At Mackinac they first saw birch-bark canoes, which, upside down, were serving as sleeping quarters for the Indians. Captain Scott, the commander of the fort and a noted hunter of the time, to whom they had letters of introduction, entertained them hospitably and introduced them to some of the salient features of the Far West. From Mackinac they went by canoe to Sault Ste. Marie, having provided themselves with buffalo robes at a cost of one dollar each. At the Sault they met Colonel Gratiot, who was on the way from St. Louis with a party of miners to explore the copper mines at Keweenah Point. The Le Contes were invited to join the party, and passed three delightful weeks at Eagle Harbor, which town they thus helped to found, taking an active part in the building of log cabins, and hunting and fishing between-times. The copper mines do not seem to have attracted Joseph Le Conte's special attention at the time.

From Eagle Harbor they again took sailing vessel to La Pointe, then an Indian agents' station and also that of the American Fur Company. Here they found a camp of about 300 Indians, whose pagan Sunday services they attended in the

afternoon, after taking part in a Christian service in the morning. Le Conte graphically describes this Indian ceremony.

At La Pointe they made arrangements for their trip to the headwaters of the Mississippi, which was to be made by canoe up the St. Louis River, thence by portage across to the headwaters of the Mississippi, which they were to descend to Fort Snelling. The crew of the 24-foot birch-bark canoe, hired from the Fur Company's agent, consisted of two Canadian voyageurs, with whom their verbal communication was somewhat difficult. Their agreement was for forty days and they provisioned themselves accordingly.

They started on July 8, passing through the group of Apostle Islands, whose wave-worn rock caverns they explored, camping one night. They then skirted the south shore to the mouth of the Bois Brulé River, and thence crossed over to the north shore, which they desired to see, and after camping there over night proceeded to the mouth of the St. Louis River, the present site of the city of Duluth. Next day began the voyage up the river, passing numerous Indian villages. While in camp at the Dalles of the St. Louis, where a long portage had to be made, Le Conte surprised a crowd of visiting Indians by swimming the rapids repeatedly; but although they cheered him, his invitation to them to join him in the exploit was not accepted. He comments on the effects of training in man as compared with animals, and his belief that "blood will tell" in physical man as well as in beasts. Farther up the river they were much annoyed by mosquitoes and "brulos," a minute sand-fly. Le Conte notes that instead of getting to drier country as they ascended to greater elevation, the ground grew marshy and dotted with shallow lakelets. A portage of a few miles then carried them to the waters of the Mississippi, and they descended to Sandy Lake, where there was an Indian agency, where they refitted for the descent of the Mississippi. Here also Le Conte raced with an Indian boy in swimming and diving, the Indian beating him in the latter art.

The voyage down the river was uneventful; Indians were frequently met and their villages used for night camps, but only one white man was seen down to the Falls of St. Anthony, a distance of between four and five hundred miles. Reaching the

falls at noon one day, they drew the canoe up on a beach at the very spot where Minneapolis was founded five years later. There was then a single log cabin, owned by a white trader. Le Conte examined with much interest the structure of the gorge below the falls, the rapids of which they "shot" in their canoe, and he even then compared the gorge to that of Niagara, as being formed by the recession of the falls from the escarpment at Fort Snelling; but, as he failed to publish these observations, the priority fell to others.

After a week's pleasant stay at Fort Snelling, during which they visited what is now known as Minnehaha Falls, on the origin of which in connection with the Falls of St. Anthony Le Conte commented at the time, they took the steamer down the river to Galena, where they stopped to examine the lead mines, also visiting Dubuque. Le Conte mentions passing a small village named St. Paul, and also Nauvoo, where the Mormon excitement connected with the killing of Joseph and Hyrum Smith was then at its height. On reaching St. Louis they found their stock of money exhausted, and had to borrow funds to enable them to return east by boat to Pittsburg, and thence by rail to New York.

At New York he resumed his medical studies—"the old grind," as he expresses it. During this time and until his graduation, in April, 1845, he became acquainted with many distinguished men, among them Giraud, Bell, Baird, and especially Audubon, whom he frequently visited at his residence, 10 miles out of the city, together with his brother John; greatly enjoying the intercourse and often boating on the river with the sons, John and Victor.

Though graduated as a physician, Le Conte did not intend to practice as such, but considered the medical course as being (at that time) the best preparation for a scientific career. His reading of the "Vestiges of Creation" about this time was his first introduction to the subject of evolution.

Going south shortly after graduation, and while making a round of visits to relatives and friends, he made a large collection of birds, which he afterwards presented to the Smithsonian Institution. Returning from a series of excursions to the mountains of Georgia in November, he planned to make a

tour through Florida on horseback with his cousin, Lewis Jones, to study the geology and natural history of that region, then little known; but this trip was brought to naught by complication with an affair of the heart, he having again met Miss Bessie Nisbet, his future wife, this constituting the second great crisis in his life. The following year seems to have been spent altogether in visits and excursions, among these one to Yonah and to Stone Mountain, returning in September to Liberty county. There he finally became engaged to Miss Nisbet, whom he married in January, 1847. The following year was also devoted to excursions and travel, with riding, hunting, swimming, &c.

Shortly after the birth of his first child, in December, 1847, Le Conte was taken with a severe attack of measles while on a visit at Savannah. Getting up too early in the impatience to return to his wife and child, his recovery was slow and tedious, and it was several years before he recovered his usual vigorous health.

But now, having assumed the responsibilities of a father of a family, he felt that it was time to terminate the free-and-easy, pleasurable life he thus far led, and he concluded that he must become "a worker in the social hive," without, however, regretting the time spent in his former pursuits, feeling that they had had a rounding and broadening effect. Not wishing to seclude his family on the plantation, he settled, to practice medicine, at Macon, Georgia, and so continued for two years and a half (to July, 1850), deriving but a very moderate income from his profession and enjoying more the instruction of a few students. He became conscious that he had not yet found his proper place in life, his taste being altogether scientific. In 1849 he read his first paper before the Georgia State Medical Society, its title being "The Science of Medicine." But he felt unhappy, as though he were wasting his life. Finally, in the spring of 1850, his cousin, Lewis Jones, visited Macon and told him of his purpose to become a pupil of Louis Agassiz, who had been appointed professor of Geology and Zoölogy at Harvard. He at once joined in this plan, the purpose being to make special preparation for the teaching of these subjects, in which he had become strongly interested through the works of Richard Owen,

especially that on the Archetype and Homologies of the Vertebrate System.

He left with much regret the circle of genial friends he and his wife had made at Macon, and in August 1850 arrived at Cambridge, where he took a dwelling-house on the Campus.

The regular session at Harvard did not open till October, but as he and his friend had come only to study with Agassiz and the latter was at home, they went right to work. "The first task Agassiz set us was very characteristic of the man. He thought awhile, then pulled out a drawer containing from 500 to 1,000 separate valves of Unio, and said: 'Pair these valves and classify into species; names no matter; separate the species.' Then he left us alone, very severely alone." They worked zealously for weeks, with an occasional silent visit from the professor. When they reported that they had done the best they could, he examined their work carefully and expressed himself much pleased, remarking to a visitor that they had just correctly amended the classification of Lea, the great authority on these shells. The same system of instruction was continued, but as they progressed their teacher became more communicative and engaged them in most interesting talks on biological philosophy.

Le Conte comments enthusiastically on Agassiz as a great teacher—one of those who are greater than all their visible results, in that their personality is magnetic and their spirit and enthusiasm contagious. To his fifteen months' intimate association with Agassiz for eight or ten hours daily, in all his excursions with Hall in the fossiliferous areas of New York, and along the shores of Massachusetts and Florida in zoölogical research, he ascribes much of the direction and success of his later work.

The exploration of the Florida coral reefs with Agassiz was especially fruitful, and he dwells upon it at length. He was most reluctant to leave his family, but, his wife urging him not to miss the opportunity, they started on the first of January, 1851. The work was undertaken at the request of Superintendent A. D. Bache, of the Coast Survey, for the investigation of the laws of the growth of coral reefs, which render navigation in the waters of southern Florida very hazardous to shipping. Le Conte and Agassiz' son Alexander, then sixteen, went as assist-

ants, the expenses being borne by the Government. They left Cambridge in a snowstorm, but during most of the six days of the voyage to Key West they sailed in summer seas, with excellent opportunities for observing marine life, from sharks to the exquisite Physalias and growths of corals.

They worked incessantly, "sometimes visiting the reefs in a Government steamer, sometimes exploring the Everglades in one direction, sometimes the Dry Tortugas in another—always observing, noting, and gathering specimens. Sometimes for several days we would be out all day on the reefs collecting, generally waist-deep in the water; then for several days we would study our specimens with the microscope, draw, and pack away. In the evenings we would gather in Agassiz' room and discuss the day's work and the conclusions to be drawn therefrom. I never saw any one work like Agassiz; for fourteen hours a day he would work under high pressure, smoking furiously all the time. The harder he worked, the faster he consumed cigars." They were greatly helped in their collecting by the sailors and 'longshore population, three or four hundred of whom took part in the task, and were greatly pleased when Agassiz manifested "almost childish glee" at some new discovery of theirs.

Longer excursions were made by the party on board a Coast Survey steamer commanded by Captain (subsequently Admiral) John Rodgers, and in a sailing vessel commanded by Captain Frye. In the latter they visited the Marquesas and the Dry Tortugas. From the latter point he was detailed by Agassiz, with Dr. Jones, to explore a small island ten miles away, where the vessel was becalmed for two days. Le Conte enjoyed the leisure time by bathing and diving in the clear warm water, gathering Gorgonias and sponges from the sea-bottom. Going back to the fort in a boat, he noted the killing of the new growths of the Madrepore corals on which the boat grounded, as a result of the annual depression of the water level; thus furnishing a basis for the determination of the age of coral reefs and islands. On his arrival at the fort he found that Agassiz had made the same observation during his absence, on reefs of Maeandrina.

The evenings on the steamer around the dining-table Le Conte

mentions as specially enjoyable, as there were on board several scientific men connected with the Coast Survey, among whom he mentions J. E. Hilgard and Count Pourtalès. On one occasion Agassiz expressed himself quite forcibly regarding the intolerance of society in America, he having experienced the effects of the *odium theologicum* on account of his views on the diversity of the origin of man; and he commended Austria as the country where a man of science could utter his views most freely, so long as he let politics alone.

The party left Key West for Cambridge after a stay of six weeks, passing from summer to winter in the course of a few days.

The main scientific results of this expedition were published by Agassiz in the Report of the Coast Survey for 1851; some extensions of the same were by Le Conte himself read at the meeting of the American Association for the Advancement of Science in 1856, and published in the Proceedings of that body, and also in the American Journal of Science for January, 1857. This publication Le Conte considers to have been his first really scientific paper.

The rest of the year was passed at Cambridge in study, as before, only even more earnestly. In addition to zoölogy and geology, Le Conte took a course of botany under Asa Gray. He and Jones still had the advantage of having Agassiz almost to themselves, some wealthy New York youths who joined the class finding themselves out of their depth and leaving very soon. In May the two friends went with Agassiz to study the New York Paleozoic in the Catskill and Mohawk region, this being the first field work in geology done by Le Conte.

In June, Agassiz suggested that the two students should take degrees at the Lawrence Scientific School, which was then in its first year and for which it was desired to make a showing. Although already possessed of three degrees, Le Conte concluded to take another under the auspices of Agassiz, and took as the subject of his thesis the Homologies of the Radiata. Upon this thesis he bestowed a great deal of thought and work. He was examined on it by Agassiz, and also publicly by him and Wyman on zoölogy and geology. Thus Joseph Le Conte, Lewis Jones, David A. Wells, and John D. Runkle formed the first graduating

class of the Lawrence Scientific School, and probably the first strictly postgraduate class in the United States. Le Conte's thesis, however, never reached publication, the manuscript being destroyed in the burning of Columbia, South Carolina, at the end of Sherman's raid.

Le Conte, however, did not stop at graduation. He continued work in Agassiz' laboratory and excursions, or by himself. The "galaxy of stars" then at Harvard was so attractive and stimulating that he hesitated to leave. There were Agassiz, Guyot, Wyman, Gray, Peirce, Longfellow, Holmes, Felton, Emerson, and also Richard Dana, whom he met three times daily at meals. Moreover, Boston being near by, afforded an opportunity for hearing and seeing the great artists of the time, such as Jenny Lind, Parodi, and others, and of attending the meetings of scientific bodies.

Le Conte designates as the third critical mental period of his life the fifteen months of his study with Louis Agassiz, and here discusses briefly the points (more elaborately presented later, in a memorial address made at San Francisco) in which Agassiz' methods of study were novel and epoch-making in the natural sciences. The new departure most widely recognized is his demonstration of the stupendous agency of glaciers in shaping the present surface of the earth; but more fundamental than this achievement is the introduction of the study of nature itself in the development of the organic world, instead of mere laboratory experimentation. The latter method is all right for inorganic nature, but in the development of organized beings experimentation introduces abnormal factors, and the observation of nature itself is first in order.

"There are three subordinate series or methods leading to similar results; these are the natural-history series, the embryonic series, and the geological or palæontological series. By the first method Cuvier and his colaborers perfected comparison in the natural-history series, laying the foundation of scientific zoölogy; Agassiz and von Baer extended the method of comparison into the embryonic and geological series and into the relation of the three series to each other. Agassiz' work and Agassiz' method prepared the whole ground for the modern doctrine of evolution, only his was an evolution not by organic

forces acting within, but according to an intelligent plan from *without*—an evolution not by transmutation of species, but by substitution of one created species for another." But he regarded the cause of evolution as being beyond the domain of science and all attempts at a causal theory as being at least premature.

Le Conte adds that Agassiz' work and method are the only foundation of the possible scientific sociology, and that in this case also three different series, corresponding to those in the lower natural organic world, can be worked out. The first series is that exhibited in different nations and races in various stages, as now existing in different places; the second, that showing the various stages in the advance of one and the same nation from barbarism to civilization, corresponding to the embryonic series; and, third, that exhibiting the slow onward progress of the whole human race through the several ages now recognized. He mentions Herbert Spencer as having taken the lead in this line of investigation.

COLLEGE AND UNIVERSITY CAREER OF LE CONTE.

Leaving Cambridge after fifteen months of residence and study, Le Conte, after paying a visit to his uncle at New York, in October took the steamer for Savannah. On arriving he learned of the accidental death of his eldest brother, Lewis. After some months passed at the plantation, Le Conte received a call to a professorship of "the Sciences" at Oglethorpe University, at Midway, Georgia. He was to teach all the sciences except astronomy, and all for a thousand dollars. But he concluded that he must now begin his life-work and accepted, teaching mechanics, physics, chemistry, geology, and botany. Zoölogy, for which he had specially prepared himself, was no part of the curriculum, and, moreover, there was no laboratory, so the work was almost wholly intellectual; but he felt that he made a successful teacher.

The previous year his cousin, Lewis Jones, had been appointed professor of geology and natural history at the University of Georgia, at Athens—a position Le Conte had also desired—with double the salary. Jones did not get along well with the president, and after holding the chair for a year resigned in

disgust. John Le Conte being also a professor at Athens, Joseph wrote to him and found to his disappointment that *French* was to be superadded to the duties of the chair. However, as he read French with ease, he concluded to "qualify himself" by taking lessons in speaking from a good native French teacher. He was elected to the complex chair in December, 1852, and began his duties in January following. A French teacher being elected after six months, he was able thereafter to restrict himself to geology and botany, with a Monday-morning class in natural theology. This latter class he enjoyed, as it gave him the opportunity to bring out the general laws of animal structure as evidence of a divine plan; otherwise zoölogy formed no part of his subjects, and to this he did not object, as the colleges were not at that time prepared for the teaching as practiced by Agassiz. Altogether, with his brother John, McCay, and later Leroy Brown and C. S. Venable as his colleagues, he was well pleased with his situation at Athens.

During the long winter vacation of 1854 Le Conte went to Philadelphia with his family, and there met many prominent men, among others Lea, Phillips, Elwin, and John Fraser. The latter one evening brought with him a then new instrument, the stereoscope, showing its effects and elucidating the theory of Wheatstone, which attributes the result to a mental (subjective) combination of the two images. Le Conte noted that when he looked at the distant lines of the images the nearer ones appeared doubled, and *vice versa*, proving that the effect is a physical one; and he so stated to the company assembled. They, however, thought him a very forward and disputatious young man for daring to dissent from Wheatstone. He did not publish his conclusions, which were a year after brought out by Brücke in Germany.

Going afterwards to Cambridge, they were invited by Agassiz to stay at his house, where they passed a delightful week, meeting also many distinguished men.

During the four years Le Conte remained at Athens (1852 to 1856) he published a number of papers, popular, scientific, educational, and philosophical. The most important of these was that "On the Agency of the Gulf Stream in the Formation of

the Peninsula of Florida," based on his own and Agassiz' observations, which created marked interest.

Between 1854 and 1856 administrative difficulties led to the resignation of several of the best men of the faculty of the Athens institution and the final removal of all by the board of trustees. Le Conte immediately applied for the professorship of chemistry and geology in the College of South Carolina, then vacant. He was elected, and assumed the duties of the chair in January, 1857. He thus again became the colleague of his brother John and of McCay, who had become president. In this position he remained until, after the Civil War, he was called to California.

In the interval between his resignation from the University of Georgia and removal to Columbia, he was invited by Prof. Joseph Henry to deliver six lectures at the Smithsonian Institution. Three of these were on "Coral Reefs" and three on "Coal." The latter were subsequently written out by him and published in the Smithsonian Report for 1857. They excited a good deal of interest and were translated and published in French. He there brought out some views on the affinities of Gymnosperms, which anticipated by thirty years the same brought out later by Lester Ward and Engler.

The work at the South Carolina College was very exacting at the time and gave no opportunity for original work, he having also had to take a class in mathematics. Shortly there occurred a cataclysm similar to that at Athens, ending likewise in a wholesale resignation of the faculty, of whom, however, the two Le Contes and one other were immediately reëlected by the trustees. The college was thus disbanded in May, leaving four months vacant until the regular opening in October. Most of this time was passed by Le Conte and his family at the Virginia Springs, where they met many of the faculty of the University of Virginia, among whom Le Conte mentions McGuffy as specially interesting. In August both Le Contes went to Montreal, to the meeting of the American Association for the Advancement of Science, at which the writer of this memoir first became acquainted with them. Joseph Le Conte mentions as the prominent event of that meeting the reading by James Hall, the retiring president, of a paper on "The Formation of Moun-

tain Chains by Sedimentation," containing a new and very important idea, but imperfectly set forth, so as to be hardly understood, although it forms the basis of our present views.

Most of the former faculty of the South Carolina institution having been reëlected in September, a little later Judge A. B. Longstreet was elected president. Their success of the year before having made the students somewhat turbulent, another strenuous period was foreseen and realized, resulting in the suspension of nearly half the students for one term. Most of these subsequently returned under rigid conditions, and Le Conte comments upon the rigid sense of honor and veracity that manifested itself among the students on all these occasions.

Stimulated by the intellectual and social surroundings in Columbia, where he met daily such men as Dr. Thornwell, Dr. Palmer, Wm. C. Preston, Wade Hampton, and others, he wrote between 1857 and 1860 many articles, mostly of literary and philosophical nature, such as "The Place of Geology in a Course of Education," "The Relation of Morphology to Fine Art," "The General Principles of a Liberal Education," "Female Education," "The Relation of School, College, and University to One Another and to Active Life," "The Relation of Biology to Sociology," and "The Nature and Uses of Fine Art." The first four of these were given as addresses before academic audiences; the others, put into a drawer for the time, were subsequently published in various reviews and magazines.

In pure science he wrote and read at the meeting of the American Association for the Advancement of Science, 1859, his original paper on "The Correlation of Physical, Chemical, and Vital Force and the Conservation of Force in Vital Phenomena." This paper created great interest among scientific men at the time; it was widely republished, both in America and in European Journals, and also in the International Scientific Series.

During a summer vacation spent in the mountains of North Carolina, Le Conte met Langdon Chevis, a planter on the South Carolina coast, who, having read the "Vestiges of Creation," heartily endorsed the origin of species by transmutation of those previously existing, while Le Conte held Agassiz' view of creation according to a preordained plan. Chevis combated so successfully Le Conte's objections as to make a strong impression on his mind, in advance of the publication of Darwin's book on

the subject; but Chevis did not think of publishing his views, which, as Le Conte remarks, was a general habit in the old South and prevented him, as well, from publishing, first, a number of observations subsequently brought out by others.

He refers with much admiration to Donati's comet of 1859, but did not, like not a few people both in and out of the South, suspect in it the forerunner of the civil commotion then impending.

WAR EXPERIENCES.

Le Conte devotes 50 pages of his autobiography to the events of the Civil War and the graphic relation of his personal experiences in connection with it, which were both extensive and exciting. Of these experiences a short outline only can, of course, be given here.

Like a great many thoughtful men in the South, especially those not in political life, Le Conte was at first exceedingly reluctant to join in a movement which foreshadowed the disruption of the Union; doubtless the more as from his personal knowledge of the North he must have been fully aware of the futility of the prediction and assertions made by the professional agitators for secession, that "the Northern mudsills have no stomachs for fighting," and that "one Southerner can whip three Yankees any time." Had the dreadful conflict which resulted been generally foreseen, these agitators would not have had such easy work in carrying the masses with them. But, as Le Conte says, it came to be a spiritual contagion, and the final result was enthusiastic unanimity of sentiment throughout the South, with a few honest exceptions. Le Conte characterizes as absurd the designation of the Civil War as the "War of the Rebellion." It was a war between two fully organized States, which was honestly fought out to a finish and the result frankly accepted. But "to us it was literally a life-and-death struggle for national existence, and doubtless the feeling was equally honest and earnest on the other side." In this spirit Le Conte took up and participated in the contest so far as in him lay, and his war experiences are highly interesting reading.

The South Carolina College went on quietly during 1860-1861, but in the spring of the latter year the siege of Fort

Sumter caused a large number of students to leave college to join the army; nevertheless the college exercises went on. In the spring of 1862 the increasing stress of the war left the college with only 40 or 50 students. In June, 1862, after the seven-days battles in Virginia, there came a call for all men above eighteen years, and perforce the college was disbanded, all the students volunteering. Both the brothers Le Conte went on to Richmond to help nurse the sick and wounded, among whom was a brother of Joseph's wife. He himself took the typhoid fever. After three weeks' illness he and his brother-in-law returned to Columbia.

While the professors' salaries were continued, they proved woefully inadequate, on account of the depreciation of the Confederate currency; so they had to complement them by outside work. In October, 1862, Le Conte was appointed one of the arbitrators to determine the right of the Confederate Government to the niter caves in the several States, and sat on the case in Atlanta for three weeks. In 1863, during the height of the conflict, he wrote the paper on "The Nature and Uses of the Fine Arts;" but, anxious to render some effective service, he took the position of chemist to a large manufactory of medicines for the army, which was established in the suburbs of Columbia, and so continued for eighteen months. In 1864 he was appointed chemist of the Niter and Mining Bureau, with the rank and pay of major. Under this mandate he explored in summer all the niter caves and beds in the Gulf States of the States west of Mississippi, as well as the iron mines and furnaces at Shelbyville, Alabama. Returning to Columbia in September, he sent a report to the chief of the Niter Bureau at Richmond.

At this time Sherman's army was moving from Chattanooga towards Atlanta and the coast. Le Conte's widowed sister and family and one of his own daughters being then on a plantation near Halifax, south of Savannah, he set out to rescue them; but within ten miles of Savannah he had to turn back to Columbia, whence, by a detour of 850 miles to southward, he again attempted to reach his sister. After many delays from hostile parties and natural difficulties, he finally reached her house one morning; but, as it was clearly impossible to escape in wagons, he started out with his daughter on an old, broken-down horse

abandoned by the Federals, lent him by a negro. They soon found themselves cut off, and after hiding in the woods for some time and having several narrow escapes from capture, they were advised by a negro that several wagons had come from the Confederate lines under a flag of truce to carry away the ladies. As all, however, could not go at once, Le Conte had to return for his sister later, the entire party to meet at Macon. This trip proved an arduous one. At Macon they were materially assisted by a young man in Confederate uniform, who seemed to know everybody in both armies. Leaving the party at Augusta, he said he would meet them again at Columbia, "whither the Federal army was sure to go." They finally reached Columbia, nearly two months after Le Conte had started out on his voyage of rescue.

The situation at Columbia being very precarious under the rapid advance of Sherman's army and the bitterness entertained by the Federals toward the "cradle of secession," Le Conte received orders from Richmond to ship the chemical laboratory to that place. A universal panic prevailed and the departure of army trains put him on guard in respect to his family; and the young man who had previously traveled with them was on hand, as promised, and advised them to save at once what they specially valued. And so lecture notes, manuscripts, &c., went off with the belongings of the Niter Bureau. The two Le Conte brothers, being Confederate officers, could not remain without being taken and treated as prisoners of war. Under the distant booming of Sherman's guns, they started with five heavily loaded wagons, accompanied and greatly handicapped by twenty-two negroes and their families and the deep mud caused by the rains. They were finally discovered by Federals, who, after rifling all their trunks and packages, set the remnants on fire and watched them burn. At this juncture John Le Conte, finding it impossible to escape with his son, who was just convalescing from a serious illness, gave himself up. Ultimately Joseph and Captain Green, their traveling companion, learned from the negroes that several parties were searching for them, and therefore concluded to escape during the night. Walking rapidly and silently towards Columbia, they soon heard Federals galloping on their trail and quickly hid behind a "worm" fence,

the other side of which was presently selected by the searching party for a rest. But after half an hour they left on the back trail.

After several days of hiding in the pine woods, they finally heard that the Federals had left Columbia, and with other returning fugitives they took the road to the city.

Entering Columbia, Le Conte found all along the main street a heap of ruins, but the college buildings had been spared. At his home he found all living and well, but much exhausted by the terrible experience they had undergone in the burning of the city, although not a soldier had crossed their threshold. So the goods they laboriously carried off and lost would have been safe in the house. The mysterious young man had slept in the basement, and had authoritatively protected the house. Whether he was a Confederate or a Federal spy, or both, was never made quite clear.

The first year following the end of the war was a trying one. For a week the family lived on provisions that had been saved from the sack of the city by the negroes that lived on their lot. Then for a while they drew rations from the city, and gradually supplies came in from the country. At one time Le Conte obtained from the Federal commander permission to go down the river on an abandoned flatboat to obtain corn for the city from the plantations below, and brought back several thousand bushels, of which one hundred was allowed him as a perquisite for himself and his brother John. Everybody of course wore "homespun," or soldiers' clothes picked up from the hospitals.

Worse than these privations was the "reconstruction" period which followed, with negro domination, aggravated by "carpet-bag" officials and their swarms of predatory followers. Of this period Le Conte forbears to speak in detail.

Having lost everything but his land in the war, the resumption of college work in 1866 greatly relieved him by the salary being also revived. Instruction in the college was now made as "practical" as possible, he himself supplementing his chemistry course with short courses on pharmacy and agriculture. Meanwhile Le Conte also resumed his outside scientific activity. In 1866-1867 he gave six lectures on "Coal and Petroleum" in the Peabody Institute at Baltimore and wrote three papers on the

"Adjustments of the Eye," "Rotation of the Eye on the Optic Axis," and "The Horopter." These were published first in the American Journal of Science and in the Philosophical Magazine, and subsequently, with nine additional articles, were embodied in the volume "Sight" of the International Scientific Series, in 1880 and 1897.

A measurably satisfactory political and social condition existed until the establishment of the permanent "civil" government, which became more and more intolerable until, in 1876, by an uprising of the people, good government was restored; but in the meantime a good many of the best men emigrated to escape the intolerable misgovernment, and the two Le Contes themselves thought of trying their fortunes with Maximilian of Mexico. Just then they heard of the organization of the University of California and applied for positions there. Both were elected in November and December, 1868, and moved to California the following year.

LIFE AND WORK IN CALIFORNIA.

Leaving Columbia after thirteen years of service, Joseph Le Conte took his family to California on the transcontinental railroad, then newly opened, and was met at Oakland by his brother John, who had preceded him and was acting as president pending the election of a permanent incumbent by the regents. Both entered on their active duties on September 20, 1869, with a total of 38 students in attendance. At the university, which was then located in Oakland, Joseph Le Conte's lectures were on geology, zoölogy, and botany.

He was greatly impressed and interested by the novelty of the country and climate and the busy, active population; and in order to become acquainted he frequently lectured publicly, thus altogether finding his intellectual activity stimulated to the highest degree. At the Mechanics' Institute of San Francisco he gave about twenty lectures on various scientific subjects, and at Oakland on Sundays he spoke on the "Relations of Science to Religion," a subject which continued prominent in his mind to the last. The stenographic report of the Oakland lectures formed the basis of his first book ("Religion and Science"), published by the Appletons not long afterwards.

Geology had now become his favorite department, but as the understanding of the geology of a new country requires more time and travel than he was able to bestow upon it, his scientific activity continued specially in the line of binocular vision. He thus followed up his first paper on the subject, written in reply to the papers of Claparède and Helmholtz, by three others published in the American Journal of Science in 1871, the last ("On the Theory of Binocular Relief") being also published in the Archives des Sciences. It gave rise to discussions with Pictet and Tyndall, in which, according to the present state of the subject, Le Conte's views were fully sustained.

During the summer vacation of 1870 he, in company with Prof. Frank Soulé and eight students of the university, undertook a six weeks' camping trip in the Sierra Nevada, which he considers almost an era in his life. It was made in the roughest style, without even a tent, each man carrying his bedding, &c., behind his saddle. They visited the Yosemite, the High Sierra, Lake Mono and the neighboring volcanoes, and Lake Tahoe. The trip was thoroughly enjoyed by all, and the opportunity afforded him for the study of mountain structure and origin formed the basis for ten or eleven papers subsequently published by Le Conte. A narrative of this expedition was published in 1875, under the title "A Journal of Ramblings through the High Sierra," which attracted much attention and, being soon out of print, was republished in 1890 by the Sierra Club of San Francisco.

The summer vacation of 1871 was utilized by him for a trip through Oregon, Washington, and British Columbia, observing systematically the many important geological features of that region; these observations he supplemented by a trip, taken more leisurely, in 1873, to eastern Oregon, including the Columbia and Deschutes rivers and the John Day region. These explorations gave him the material for what he considers one of his most important papers, that on "The Great Lava Flood of the West and the Age and Structure of the Cascade Mountains." This paper made known for the first time the enormous extent of what is probably the greatest continuous eruptive sheet in the world, and gave its beginning as probably at the end of the Miocene.

During the fall of 1872, after his return from the second trip to the Yosemite, Louis Agassiz visited him in Oakland, having come around Cape Horn in the Coast Survey steamer *Hassler*. This visit was of course a great enjoyment to Le Conte. Agassiz died in Cambridge a year later, and Le Conte made one of the memorial addresses before the Academy of Sciences in San Francisco, as already stated.

During the summer vacation of 1874 he, with his family, spent some time at Lake Tahoe, and availed himself of the opportunity to study the tracks of ancient glaciers in the region, with their moraines and lakelets. The results of these observations were given in a paper "On Some of the Ancient Glaciers of the Sierra Nevada," published in the American Journal of Science in 1875. He also at that time visited the Comstock Lode, which formed the basis of four or five papers subsequently published.

In the fall of 1874 he, with others of the university faculty, took up residence at Berkeley, the permanent site of the institution, then consisting of a few houses, but at the time of his death, in 1901, a town of 15,000 inhabitants; which number has now (1906) at least doubled. He always greatly admired and enjoyed the site of the university and town.

During the summer vacation of 1875 he again, with a party of university men, camped in the High Sierra. Their plan had been to go, via Yosemite, Lake Mono, and Lake Owen, over the Kearsarge Pass and down the Kings River Cañon; but an accident to himself prevented Le Conte from going beyond Lake Mono. There he made detailed studies of the volcanic phenomena, the results of which were afterwards published in the American Journal of Science in a paper "On the Extinct Volcanoes about Lake Mono and Their Relations to the Glacial Drift." During this year he was elected to membership in the National Academy of Sciences.

The most important paper written by him in 1876 was "On the Evidences of Horizontal Crushing in the Formation of the Coast Ranges of California." The striking contrast between the structure and details of the origin of the Sierra Nevada and the Coast Range was always a favorite topic with him, and he used to cite the latter as an irrefragable proof that, whatever differ-

ence of opinion there might be as to the *cause* of the horizontal pressure, no one seeing the phenomena shown in the Coast Range strata, even within a short distance of the University of California, could question the fact that they could not be explained by forces acting in any other way.

An address on "The True Idea of a University," made during this year, at commencement, and subsequently republished in the Princeton *Review* and the University of California *Chronicle* in modified form, is characteristic of Le Conte's ideals in respect to the means and methods for the best and highest intellectual and moral development, so far as this can be accomplished by secular education.

Shortly after the writer's arrival at the university, in spring 1875, Le Conte asked his opinion as to the need and likelihood of success of a text-book of geology which should embody dynamic geology as its chief feature, instead of being in the main historic, as was then the case with Dana's large book. Having experienced, while teaching at the University of Michigan, the great need of such a work, the writer strongly urged upon Le Conte the publication of such a book, which he had already begun to write and subsequently pushed vigorously toward completion; so that in 1876, when he went east to visit the Centennial Exposition, he entered upon negotiations with the Appletons for its publication. At Philadelphia he was especially interested in the inspection and trial of the telephones, then newly invented, especially that of Bell; which occurred in the presence of Lord Kelvin, the Emperor and Empress of Brazil, and other distinguished men. He subsequently, on his return to Berkeley, gave a lecture to the students and faculty of the university, in which he explained the principles and action of the Bell telephone, exciting great interest.

Upon the completion of the manuscript of the "Elements of Geology" he, in April, 1877, sent it on to the Appletons, who agreed to publish it provided that he would personally superintend the making of the engravings and the printing. He went to New York in May and worked very hard for three months. By August all was done except the proof-reading of the last half, which was done by him at Berkeley. The book was published in January, 1878, and was from the beginning very suc-

cessful. It has remained a standard college and university text-book ever since, and has gone through four editions, revised by himself, the last in 1902. It has since Le Conte's death been revised and supplemented so as to include the latest researches, by Prof. H. Leroy Fairchild, of Rochester. Its original character has, however, been faithfully preserved, and it remains probably the most widely used text-book of geology in the English language; for, although no written treatise could even approximately represent the eminently "live" lectures which the book embodies, yet, in so far as this is possible, the style reflects everywhere the intensity and geniality which made Le Conte's lectures so deservedly popular, both with the students and the public. His courses always varied from year to year, never becoming stereotyped, but always fresh and newly interesting, even to those who had heard the same subjects treated by him before; and he always prepared himself fully for each lecture. In this personal intensity lay the secret of his great popularity and influence with his students, and he states emphatically the principle, now at last becoming widely accepted by the American universities, "that investigation should never be separated from teaching, as many propose; for not only is one a better teacher for being an investigator, but also a better investigator for being a teacher. We never know any subject perfectly until we teach it." To his intense interest in his subject, and in his students, Le Conte attributes most of his success in teaching, which in the course of time became so great that there was no lecture-room in the university sufficiently large to hold his audiences. These came from all the nine "colleges" into which the university differentiated in the course of time, with the twenty-four hundred students actually present at Berkeley at the time of his death, in 1901, as against the thirty-five in 1873. Le Conte alludes regretfully to the diminished efficiency of instruction resulting from this enormous increase, occurring simultaneously all over the United States, but without a corresponding increase in the means available for instruction, and rendering personal contact and influence of instructors with the students very difficult.

Among the influences which kept up his wide, active interest in many directions, he mentions among his colleagues Hilgard,

Moses, and Howison, the latter especially, with whom he differed quite radically in many points, especially as regards the scientific as contradistinguished from the metaphysical standpoint in philosophy. He justly attributes a great intellectual stimulus to the Philosophical Union established by Howison in the university, where he with others frequently held ardent discussions on philosophical subjects. Another strong stimulus was, and is today, the "Berkeley Club," founded in 1873 by President D. C. Gilman, and which Le Conte considers an ideal club for intellectual stimulation and broadening; consisting, as it does, not only of university men of all departments of knowledge, but embracing also educated men of all pursuits, professions, and opinions. It is, as he says, a club of diverse spirits, where we may get, directly and without much labor, the best results of thought in other departments. It is therefore, within its membership, a powerful promoter of broadness as against the modern tendency to excessive, narrow, and premature specialization, which Le Conte considers as one of the prime evils of modern intellectual, and specially of scientific, life, productive of prejudice, self-conceit, and lack of sympathy between diverse pursuits. "The Berkeley Club combines the best features of both social and intellectual clubs, there being a fortnightly dinner, and after that a paper by some member (in rotation) and a general discussion thereon." It was doubtless this continual friction with diverse opinions that led him to decline special affiliation with any of the existing denominational churches, though tolerant and sympathetic toward all and contributing habitually to several of their number.

It was in this attitude of mind, gradually matured during the thirty years of his residence in California, that the greater part of his intellectual and scientific work, of which the enumeration and discussion follows, was done.

A summary historic recital of his chief activities during his life in California must suffice, in order to leave room for a fuller connected discussion of his most important writings.

In 1877 he wrote one of his most important papers, "On the Critical Periods in the History of the Earth, and the Quaternary as Such a Period." This idea had long been in his mind, and it was subsequently greatly enlarged by his discussion of the

Ozarkian or Sierran era of elevation and erosion, published in 1900. These are discussed later. In the same year he wrote his first discussion of the "Glycogenic Function of the Liver and Its Relation to Vital Force and Vital Heat," which was expanded in subsequent publications and finally summarized also in his book on the "Comparative Physiology and Morphology of Animals," issued in 1900.

In 1878 he wrote a paper in reply to Captain Dutton's criticism of his "Contractional Theory of Mountain Formation," which he explained more fully. In the summer of this year he took his family on a camping trip to the Yosemite Valley and Calaveras Grove.

The summer of 1879 he devoted to an extended but rather pleasure tour with his wife to Oregon, Washington, and British Columbia, and examined the Carbon River coal fields.

Among the scientific papers written by him in 1880, a very active year, was one on "The Old River Beds of California," which further illustrated his views on the critical events of the Quaternary era. Others were on "The Genesis of Sex," "The Effect of Mixture of Races on Human Progress," and on "The Laws of Ocular Motion," the latter being afterwards made a portion of his book on "Sight," written in the same year. He also made a trip to the South.

In 1881 he made only a short trip to study the formation of cinnabar veins at the Sulphur Bank, which he saw in actual progress and discussed in a paper published in 1882. In the summer of the last-named year he also made another trip to the Yosemite, and while there heard of the discovery of the Carson Footprints, which he examined, together with the Steamboat Springs of Nevada. He determined the footprints as those of animals of late Tertiary age.

Spending the summer vacation of 1883 near San Bernardino, he made observations on the old river beds of the Sierra Madre, showing there also a post-Tertiary elevation of the mountains. His paper on this "Rejuvenation of the Sierra" was not published till 1886.

In 1884, after having in New York superintended the publication of his "Compend of Geology," he again visited the South. During this and the following year he wrote many short papers,

but the work of chief interest was his excursion with Captain Dutton, of the United States Geological Survey, first to Mount Shasta, and then to Oregon, to the lava fields and Crater Lake, in the old crater of the exploded Mount Mazama, whose lava they found quite different from that of the lava fields proper. They also examined Klamath Lake and its origin in a fault. Le Conte greatly admired the scenery and was deeply interested in the geological problems offered in that region. On his return he immediately began to write out his views, thus confirmed, on the "Post-Tertiary Elevation of the Sierra," which was read before the National Academy of Sciences in 1886.

In the summer of 1887 he made a trip to the lava fields of Modoc and northward, via Reno, and Pyramid and Winnemucca lakes, which he recognized as remnants of the former great continental twin lake, Lahontan. He also visited Surprise Valley and determined its character as representing a fault scarp. Later in the same year he wrote a paper on the "Flora of the Islands of the California Coast in Relation to Changes in Physical Geography," emphasizing the origin and effect of the deep channels separating them from the mainland.

In May, 1888, he gave the inaugural address at the transfer of the Lick Observatory, then just completed, into the custody of the University of California. During the succeeding summer vacation he, with his family, once more visited South Carolina.

During the summer vacation of 1889 he undertook an extended trip into the Sierra Nevada, entering via Yosemite Valley, Tuolumne Meadows, Mono Pass, Mono Lake, &c., ground already familiar to him, but nevertheless greatly enjoyed, in company with his son Joseph (who subsequently became a most expert mountaineer) and other University men. At this time, in crossing the hot San Joaquin Valley, he for the first time felt a waning of his physical endurance.

In 1890 Le Conte suffered a great shock and loss in the death of his brother John, with whom he had been more or less associated and linked in close friendship throughout his life. He wrote for the National Academy of Sciences, of which both brothers were members, the memoir of the life of John Le Conte.

The years 1890 and 1891 were a period of great intellectual

and scientific activity for Le Conte, involving the publication of numerous papers, both philosophical and scientific, as well as the revision and republication of previous works. He was elected president of the American Association for the Advancement of Science after thirty years' absence from its meetings. He was also made vice-president of the American committee of the International Geologic Congress, which met at Washington at the same time, and in the unexpected absence of the president, Newberry, he presided at the meetings of the Congress, and therefore had to make an address of welcome to the visiting geologists. The subject of this address, which he had to prepare within two days, was "The American Continent as a Geological Field," and in it he called the attention of the foreign members specially to the greater simplicity of geologic phenomena in the United States as compared with Europe, qualifying the American geologic field to serve as a prototype rather than the more complex European conditions, as had heretofore been done. Here he made numerous interesting acquaintances, which were to serve him greatly in a subsequent visit to Europe.

Having subsequently superintended at New York the fourth edition of his "Elements of Geology," he visited his relatives in the South, stopping afterwards at Washington, where he lectured before the Philosophical Society on "The Relation of Philosophy to Psychology and to Physiology." Subsequently, in New York, he lectured on "The Race Problem in the South"—a thorny subject at the time—which he afterwards elaborated more fully in a volume entitled "Man and the State."

The regents of the university having given Le Conte a year's leave of absence with full salary, he determined now to fulfill his wish, long entertained, of visiting Europe. He sailed in February, 1892, from New York to Genoa, with his wife and youngest daughter, Caroline. It was a great event to him and was thoroughly enjoyed. From Genoa, Rome was visited, then Naples, whose bay he compares to that of San Francisco, whose general scenery he considers quite equal, but lacking the clear blue water and the pebbly beaches as well as the historic setting. After visiting the usual points of interest, they went north, via Rome, to Florence, Venice, Milan; thence, via the St. Gotthard Pass and Luzerne, to Zürich, where he visited the university;

thence to Heidelberg and down the Rhine, which, apart from its historic castles and cities, he found less striking than the Columbia, the Fraser, or even the Hudson. After a few days at Cologne they went to Paris, where he enjoyed specially the many distinguished men he met, mentioning Gaudry, Boule, De Margerie, Daubrée, Barrois, and others. Professor Javal, the ophthalmologist of the Sorbonne, told him that where he (Le Conte) differed with Helmholtz in matters relating to sight, Le Conte was, in his opinion, altogether right.

From Paris they went to England, where Le Conte was specially delighted to hear his native tongue again. They were mostly the guests of Mr. De Friese, a former student at the University of California. Among the many interesting men he met were Professor Prestwich, whose guest he was for some days, Sir Archibald Geikie, Professor Judd, and others; and after attending a meeting of the Geological Society he was invited to a dinner, at which he met, among others, Sir John Lubbock, who showed him much attention. Sir Andrew Clark asked him immediately whether he was the author of the book on "Evolution in Its Relation to Religious Thought," which he had carefully read and annotated. Cambridge and Oxford gave him the most enjoyable experiences. Prof. McK. Hughes entertained him for several days at Cambridge, and Professor Romanes, with whom Le Conte had corresponded, invited him to his house at Oxford. It appeared, again, that Romanes had also been especially impressed with the book on "Evolution and Religious Thought."

After a much-enjoyed tour through Scotland and short stay in Ireland, where they visited the Lakes of Killarney, they went, via Cork and Queenstown, to New York; thence, after presiding at the meeting of the American Association for the Advancement of Science, at Rochester, Le Conte returned directly to California.

In winter of 1892-1893 he visited southern California, lecturing at several points.

On the 26th of February 1893, being his seventieth birthday, the Academic Senate of the University of California gave him a dinner in the Maple Room of the Palace Hotel, San Francisco. In June of the same year, being quite unwell, he visited the Yosemite Valley, and, thinking it was probably the last time he

would see it, he took leave of the familiar cliffs and water-falls. He, however, saw it several times afterwards. In August he went to Madison, Wisconsin, to give his address as retiring president of the American Geological Society. His subject was the important paper on "Mountain Origin," subsequently published in several journals.

At the beginning of the year 1894 occurred the Midwinter Exposition at San Francisco, where he addressed one of the congresses on "The Theory of Evolution and Social Progress," which paper was subsequently published in *The Monist*. He again spent the summer in the Yosemite Valley, but this time at the hotel, and then, in August, attended the meeting of the American Association for the Advancement of Science, at Brooklyn, New York. He shortly after became a member of the American Institute of Mining Engineers, in recognition of his paper on "Posepny's Genesis of Ore Deposits."

In 1895 he attended the meeting of the American Educational Association at Denver, giving an address on "The Effect of the Theory of Evolution upon Education," published in the proceedings of that meeting. In this year he also, after participating in the discussions of the "Concept of God" by the Philosophical Union of the University of California, wrote the summary of his address, which was finally, with those of Howison, Royce, and Mezes, published in a book by the Macmillans. He also wrote, by invitation, a memoir of the life of J. D. Dana, which was read at the meeting of the Geological Society of America and subsequently published as a bulletin, and also in Dr. Gilman's "Life of Dana."

In January, 1896, he gave up his undergraduate classes, which had become excessively large, and thenceforth gave mainly graduate courses in geology and comparative physiology. This change he greatly regretted, for he enjoyed the undergraduate teaching; but the revision of examination papers became too irksome.

In this year the students began to take notice of his birthday, which until his death was manifested by decorating his room and lecture-table and by the giving of some valuable present, among which was a portrait of Agassiz. Even when, in 1901, he was absent in Georgia, he received a congratulatory telegram from

the students; and for a number of years after his death, formal memorial exercises were held on that day.

The year 1896 was a very prolific one with him, his first paper being on "The Relations of Biology to Philosophy." This paper was read at a number of philosophical meetings at the East also, and subsequently published, without his permission, and with many misprints, in *The Arena*. Later he wrote an article entitled "From Animal to Man," published in *The Monist*. In summer he attended the meeting of the American Association for the Advancement of Science at Buffalo, and presided over that of the Geological Society of America, which was notable because it was in honor of the sixtieth anniversary of Prof. James Hall's activity on the geology of the State of New York. Le Conte delivered one of the addresses, which was subsequently published in *Science*.

After supervising the new editions of his "Elements of Geology" and his book on "Sight," he early in September sailed for England. The special object of this trip was to attend the Liverpool meeting of the British Association for the Advancement of Science, to which he had been specially invited. Here he met many old friends and made a number of new ones—among others, Herbert Spencer, who invited him to luncheon; also Mr. Carnegie, who invited him to the privileges of the Athenæum, in London.

Le Conte's stay in England was brief, as he was to be present at the sesquicentennial celebration of the College of New Jersey, on changing its title to that of Princeton University. Here the title of LL. D. was again conferred upon him, and esteemed by him a distinguished honor.

After the celebration he visited Harvard University as the guest of his former pupil, Josiah Royce, and spent a fortnight among many old friends, including Mrs. Agassiz, Alexander Agassiz, Mrs. Asa Gray, and James Peirce; dining also with a "Berkeley colony" of twenty or more former students.

After attending the meeting of the National Academy at New York, in November, he presided at the meeting of the Geological Society in December. At the latter meeting he gave an address on "Crust Movements and Their Causes," which was printed

as a bulletin of the society and also in the Report of the Regents of the Smithsonian Institution for 1896.

Immediately after this meeting he joined his wife and daughter in the South, and celebrated his golden wedding at the house of his elder daughter, at Scottsboro, only two miles from Midway, where the marriage originally took place. All the children and grandchildren, with many other friends, attended the happy occasion, which was still further enlivened by numerous telegrams, presents, and congratulations from the regents and faculty of the University of California, and other distant friends. Subsequently, on his return to California, a public reception was given him and Mrs. Le Conte by the alumni of the university, with the presentation of a golden loving-cup, at the Hopkins Art Institute; followed later by a dinner given by the faculty.

The summer vacation of 1897 he again passed in the Yosemite Valley, his son and daughter camping. He also made an excursion to Clouds Rest and the Little Yosemite, and he once more thought it would probably be the last time that he should see these wonders.

In 1898 he published a new and revised edition of the "Compend of Geology" and on Charter Day delivered an address on "The True Idea of a University," subsequently printed in the *University Chronicle*. He also contributed to the Philosophical Union's discussions on "The Will to Believe," and a paper on "The Religious Significance of Science."

During 1899 he wrote and published in the *Journal of Geology* what he himself regards as one of his most important geological papers, on "The Ozarkian and Its Significance in Theoretical Geology," which discusses the important unconformities and erosions due to extended oscillations of the continent at the beginning of the Quaternary era.

In January and February, 1900, he published, in the *Popular Science Monthly*, a popular article entitled "A Century of Geology," wherein he traces the evolution of geologic thought during the nineteenth century; illustrating strikingly its development from mere infancy to the commanding position it now occupies among the natural sciences, notably its influence upon general scientific as well as philosophical and religious thought;

overcoming one after another the various phrases of opposition by the invincible logic of its facts and logical inferences therefrom, and later substituting for the cataclysmic theories entertained at first, the conception by Lyell of slow and measured agencies, as observed today; which was in its turn modified by the recognition of "critical periods" occurring from time to time, when changes were rapid and intense.

Feeling in good health and spirits, despite his 77 years, and yearning once more for the High Sierra, he joined a camping tour undertaken by his son Joseph into the Kings River Cañon. He was in camp for six weeks, part of the time at an altitude of 11,000 feet and once at 12,000, he being in perfect health all the time and greatly enjoying himself. An account of this trip was published by him in the October number of *Sunset,* 1900.

Having again been given leave of absence for one year by the regents, in order that he might attend the congresses of the natural sciences which were to meet at Paris at the close of the century, he made preparations to go, but gave it up on account of the ill health of his daughter Caroline. In September, nevertheless, he went to New York with his wife to cross the Atlantic, but was himself taken ill with the grippe and had to relinquish the voyage. He then went South, to his elder daughter's home, soon recovered, and spent the winter among his children and grandchildren. He still hoped to go to Europe in the spring, but his wife yearned for home, and they returned to Berkeley in March. As his son was to marry in June, he finally relinquished the European trip.

After the wedding, which was also attended by his eldest daughter, Mrs. Davis, long a resident of South Carolina, he determined to revisit the Yosemite Valley in company with Mrs. Davis, who had never seen it. Mrs. Le Conte was anxious about the effect of the trip upon his reduced strength, but her objections were overcome by his enthusiasm and ardent wishes, and so he left home in June, 1901, for his eleventh visit to the wonderful valley, via Wawona and the Mariposa Grove. On July 3 he arrived at Camp Curry, the rendezvous of the Sierra Club, somewhat fatigued, but joyous and enthusiastic as ever.

Professor Frank Soulé, of the University of California, one of his companions on this trip, as he had been thirty-one years be-

fore, thus describes the events of these last days of Le Conte's life:

"He spent the next two days driving around the valley with his daughter and her friends, in walking to objects near at hand, or, during intervals of rest, in chatting with his numerous friends and the strangers who insisted on meeting him. He was geniality and hospitality personified, a Southern gentleman of the old school, and undoubtedly his physical strength was thus severely overtaxed during these two days. The history of his earlier trips, his hypothesis of the formation of the valley, and geological questions innumerable, were all gone over patiently for the edification of his ever-gathering listeners. But nature gave out at last. On the evening of July 5 the sad words were whispered around camp that 'dear Dr. Joe is very ill.' He was in great physical pain, caused by *angina pectoris*, but his daughter and their intimate friends did everything possible throughout the night to alleviate his sufferings. In the morning he seemed to be resting comfortably, so much so that his physician left his bedside to procure additional medicine from the hotel. At 10 a. m. Dr. Le Conte turned on his left side. His watchful daughter at once noticed a great change coming over his face, and said, 'Do not lie on your left side, father; you know it is not good for you.' He smiled and uttered his last words in life, 'It does not matter, daughter.' In five minutes he was dead.

"Only 24 hours previously he had visited with his party the picturesque Vernal Falls, and while there had good-humoredly consented to be photographed, affording the last picture of him ever taken."

Scores of friends quickly gathered, and university students and graduates prepared his casket, bound it upon the stage-coach, and covered it with laurels and pines. Thus Joseph Le Conte set out on his last return from the valley, escorted by his daughter and one friend.

The funeral, which took place on July 13, was a remarkable manifestation of the respect and affection in which he was held, not only by all connected with the University of California, but also by the people of the surrounding cities and of the State at large. Many came from long distances to pay this last tribute of respect to Joseph Le Conte; the regents, faculties, and

students of the university, where all exercises had been suspended for the day, and a long line of carriages formed an imposing procession, accompanying the body to Mountain View Cemetery, near Oakland, where it was interred alongside of his brother John. A few months later the grave was marked with a large granite boulder procured by the Sierra Club from the vicinity of the camp where he died, in the Yosemite Valley.

On August 21 following, at the opening of the academic year, memorial exercises were held in the presence of a large audience in the hall of the Harmon Gymnasium, addresses being delivered by members of the faculty, alumni, and students. Memorial ceremonies still continue to be observed annually, at the University, on February 26, Joseph Le Conte's birthday, at the foot of a venerable oak dedicated to the two brothers by the students.

Joseph Le Conte is survived by his wife, three daughters, and one son.

Digest of Joseph Le Conte's Major Writings.

1. SCIENTIFIC PUBLICATIONS.

A. Geological.

Le Conte's first geological paper after his arrival in California was evidently suggested by his observations in the Sierra Nevada and the Coast Range, in 1870 and the next succeeding years. His "Theory of the Formation of the Great Features of the Earth's Surface," published in the *American Journal of Science* in November, 1872, outlines essentially the views which he presented more elaborately in later papers on related subjects, notably in his "Reply to the Criticisms of T. S. Hunt" on the above paper (1873), and later in that on "Evidences of Horizontal Crushing in the Formation of the Coast Range of California" (1876). In the first of the above papers he formulates into a definite theory the ideas theretofore advanced by Hershell, Scrope, Lyell, Hunt, and Hall, viz., the solidity of the earth's interior and the aqueo-igneous fusion of the deeply buried sediments by the rise of the geo-isotherms. At this point Le Conte adds the important suggestion that such fusion created lines or belts of weakness, which, with the effect of secular

contraction of the earth, caused the formation of mountain chains within the zones of greatest thickness, and their complex folding by lateral pressure and upswelling. Hunt's reclamations of priority are discussed in the second paper, together with clear formulations of the essentials of his views, and their correlation with the occurrence of fissure eruptions and volcanoes in connection with such chains. He also calls attention to the impossibility of supposing the Appalachian plateau to have been formed as a convexity, that form being necessarily a subsequent result of an extended ("epeirogenic") upheaval. He sums up by the formulation of his theory of mountain formation as follows: Accumulation of lines of thick sediments where subsidence occurs; rise of geo-isotherms, causing aqueo-igneous softening, which determines lines of weakness and yielding; then crushing horizontally and swelling up vertically forms the mountain chain. But when once the yielding begins, mechanical energy is changed into heat, which may thus be increased to any extent and produce true igneous fusion. In the last-mentioned effect he, with J. D. Dana, accepts the views of Robert Mallet. In subsequent papers as well as in his book on the "Elements of Geology," he of course completes this theory by reference to the resultant fissure eruptions, followed by the establishment of volcanoes as the remnant of the energy of fissure eruptions, and the final erosion into the present forms of mountain chains; but he admits his inability to account for the local oscillations of level, which are so obvious in the past and are still in progress.

In his paper on the "Formation of the Coast Range of California" (1876) he illustrates, and fortifies by many observations and examples, his previous conclusions. He discusses specially his observations of the numerous rounded and elongated, flattened concretions of the cleavage surfaces of shales, evidently originally clay pellets, which have experienced the effects of lateral pressure and corresponding vertical upswelling. He shows that every 2½ to 3 feet of original horizontal strata were here compressed into one foot, with corresponding vertical upswelling. Slaty cleavage was here not produced at right angles to the pressure, owing to the coarseness of materials; but in the foothill slates of the Sierra Nevada the slaty cleavage is nearly throughout parallel to the stratification.

He also refers to the criticism made by Dana, that he (Le Conte) underestimates the amount of elevation caused by plications, and claims that on the supposition of a solid earth, the elevation by compression will be the same with as without folding, and that if fissure eruptions occur, the same will be true.

Le Conte's paper "On the Great Lava-Flood of the Northwest, and the Structure and Age of the Cascade Mountains," written in 1874, after his second exploration of that region, adds important illustration and corroboration to some of the points previously made by him. In his two explorations he conclusively established the enormous extent and thickness of the Northwestern eruptive sheet, and the beginning of its extrusion toward or at the end of the Miocene. He concludes that while a low range may have been formed synchronously with the Sierra Nevada, in Triasso-jurassic times, it was subsequently overflowed and submerged by the great lava-flow, causing the striking contrast between the jagged summit-lines of the Sierra and the almost level, plateau-like crest of the Cascades, varied only by the volcanic cones superimposed upon it. As to the mode of formation of the great eruptive sheet, he accentuates the fact that inasmuch as mountain ranges are admittedly formed as the result of lateral crushing and vertical upswelling, it is natural that when the stress occurs after a protracted solidification of the crust, fissures must be formed and the sub-mountain liquid or viscous matter, probably formed by local crushing, must be squeezed out. He also calls attention to the difference in the physical condition of the great eruptive sheet and the vesicular lavas erupted by the succeeding volcanoes, in which steam and other gases act as a *vis a tergo*. He agrees with Dana as to the inverse ratio between folded mountain chains and fissure eruptions.

These papers of Le Conte and those published by Dana in volumes 4 and 5 of the *Journal of Science* form a remarkable body of important discussions of mountain-making. While differing in some details and in mode of statement, the essential points of the two sets of papers are in agreement, and both turn to the contraction of the globe as the necessary moving force for the lateral crushing which is in evidence everywhere.

In a later paper (1878) Le Conte replies elaborately to criticisms made by Dutton, combating the contraction of the earth by cooling as an agency in mountain-making. Later papers on the same subject appeared in the *Philosophical Magazine* (1888), in the *American Geologist* (1889), and in the presidential address delivered by him before the American Association for the Advancement of Science, 1893. The views there given are those embodied in the last edition of his "Elements of Geology," revised by himself in 1902, and do not materially differ from those quoted above.

Le Conte considers as one of his most important geological papers that on "Critical Periods in the History of the Earth and their Relation to Evolution; and on the Quaternary as Such a Period," published in 1877. It is the most comprehensive and probably the most widely interesting of his single papers, comprehending as it does the geological, geo-physical, paleontological, and evolutionary points of view, including the preëminent significence of the advent of man upon earth. It is at this time the more interesting as, by an unconscious reaction toward Agassiz' contentions, he is lead to anticipate the modern theory of "Mutation" in connection with evolution, designating the process as "the fact of paroxysmal movement of organic evolution." An organism, he says, may be regarded as being under the influence of two opposing forces, the one—heredity, rigidity of type—conservative; the other, the pressure of changing environment and conditions, aided possibly by an inherent tendency toward change. The latter may for some time accumulate but make little impression, but finally, the resistance giving way, the organic form breaks up into a number of fantastic sports, which are at once seized upon by natural selection. If for the word "sports" we substitute "mutations," we have the essentials of De Vries' views and observations, in which natural selection also soon eliminates a number of non-viable mutations.

The critical periods he discusses are those characterized by unconformities in the geological series, which he considers as marking changes in the rate of evolution, "periods when the forces of change are active, instead of potential" as in times when conformable rocks are being made. The critical periods

are periods of lost records, because they were continental; and the farther back we go in geological and human history, the longer are the gaps and the more irrecoverable the records. The first and the greatest observable break is that between the Archean and the Paleozoic. The former ends with merely protozoan life, hardly yet differentiated into fauna and flora. The primordial record opens with a varied and already highly organized fauna, including an enormous evolutionary interval. The next general unconformity occurs between the Paleozoic and Mesozoic, "the most sweeping change in the forms of organisms that has ever occurred in the history of the earth, even though partly bridged by the Permian."

Far less in time and in sweeping character is the lost interval between the Mesozoic and the Cenozoic, the Cretaceous and the Tertiary. Here conformity is not uncommon, but the break in the continuity of the fauna is very great all over the world; the relatively short interval and the great change from the crest of saurian development ending the Cretaceous, and the great mammalian evolution in the Tertiary, is so great that it can only be explained by migration from where marsupial forms had existed even from Jurassic times. The disappearance of the Cretaceous ocean and its replacement by great lakes in the Basin region was doubtless a powerful agency in bringing about these changes in America.

The early Quaternary was also to a marked degree a continental period, one of great and widespread oscillations, upheaval, downsinking and reëlevation, with unconformities on a grand scale. He discusses this interval specially in a paper published in 1899, "On the Ozarkian and its Significance in Theoretical Geology," emphasizing particularly the important unconformities and protracted and incisive erosional activity marking the interval of time between the latest Tertiary and the earliest Quaternary; when during extended continental elevations there were formed the deep and abrupt cañons of the Ozark range, the sculpturing of the coastal plain of the Gulf States, prior as well as subsequent to the Lafayette epoch; the formation of the now submerged river channels of the Atlantic coast, and, greatest of all, the excavation of the present river channels of the Sierra Nevada and of the inner cañon of the Colorado. Le Conte esti-

mates that this erosional interval must have been quite as long, and probably longer, than the Glacial Epoch itself. There were thus great changes in physical geography, permitting intercontinental migration of mammals and forcing the retreat of organic forms adapted to temperate and warm climates southward, both on land and sea; with a subsequent return of arctic forms northward and upon mountains, where they were left stranded in isolation. The disappearance of the great Pliocene mediterranean lake separating eastern from western America likewise brought about or permitted important changes. Yet great as these changes were, they are incomparably less than those of previous critical periods, in which not species but genera, families, and even orders appeared and disappeared. The conclusion is that the previous critical periods or lost intervals were far longer than the whole Quaternary, or that the rate of evolution was far more rapid in those earlier times.

In view of all the facts, Le Conte claims that the Quaternary, as a critical period, should be considered as separating the Cenozoic from the Present, or Psychozoic, or Age of Man. "Not that man was not in existence in the early Quaternary, just as fishes existed before the Age of Fishes. It is the *culmination* of a fauna or flora, not their first beginnings, that should be considered as characterizing an 'age.'"

Next in importance to the above papers of wide scope and interest stands that on "The Old River Beds of California," which was written by him as the result of an exploration of the Yuba River and its hydraulic mines (1880). It suggested to him the important idea of a rejuvenation of the Sierra Nevada at the end of the Tertiary—a topic which is more fully elaborated in his "Elements of Geology," pages 591 to 593.

His paper "On Some of the Ancient Glaciers of the Sierra Nevada" was based upon his observations, first made in 1874, near Lake Tahoe, which he subsequently supplemented elsewhere in the Sierra Nevada; convincing himself, among other things, of the former occupancy of the Yosemite Valley by a glacier, which Whitney had at first believed, but afterwards rejected. Le Conte bases his conclusions upon the general forms of the rocky sides of the valley and the characteristic lake-meadows marking the retreat of the glacier, even though moraines and

scorings are not much in evidence. The rapid weathering of the Yosemite granites would inevitably obliterate the latter in a relatively short time. Investigations made since in other parts of the Sierra have clearly proven the former presence of numerous glaciers of vast extent in the principal valleys of the Sierra, and Le Conte, as well as the writer, thinks that there is good evidence that even the Coast Range was at one time glaciated.

In 1881 he, in company with Professor Rising, of the University of California, made a special examination of the "Sulphur Banks" quicksilver mines, where he saw cinnabar vein-formation in actual progress. These observations were discussed in a paper published in 1882 in the American Journal of Science. In that year he also made another trip to the Yosemite Valley, and while there heard of the discovery of the "Carson Footprints," which he examined, together with the Steamboat Springs of Nevada. He determined the footprints to be those of animals of late Tertiary age. The results of these investigations were published in 1883.

B. Biological Writings.

Le Conte's book on "Sight," first published in 1881 and again in 1897, as volume 31 of the International Scientific Series, by the Appletons, is perhaps the most striking illustration of the accuracy of his habit of observation, and the best refutation of the criticism made of his geological work by sticklers for specialization, viz., that he failed to show himself a good field geologist. Undoubtedly his bent of mind lay rather in the direction of generalizations from facts, whether observed by himself or others; but when he needed additional facts for his purposes, no one was more apt and ingenious in devising and carrying out the needful experiments and observations. The power and faculty of generalization is infinitely more rare and fruitful than that of narrow specialization, but it nowise impairs, necessarily, that of accurate observation. It is when superficial knowledge attempts generalization that discredit does and should attach to it.

As regards vision, he was specially qualified by the possession of excellent, strong, and normal eyes, which lasted unimpaired to the last; enabling him, with the aid of persistent practice, to execute with little difficulty experiments that had failed with

others, and the failure of which had been made the basis of incorrect interpretations of the phenomena of binocular vision especially. Thus, at his first view of the stereoscope devised by Wheatstone he at once perceived the incorrectness of Wheatstone's subjective interpretation of the stereoscopic effect, being enabled to see the real and the phantom images simultaneously by simple change in the adjustment of the eyes. His book contains a wealth of experiments easily executed by persons with normal eyes, and most convincing in their results, yet difficult or impossible to some persons, especially to those not accustomed to close objective perception and analysis thereof.

Accepting the correctness of the experimental results as given by Le Conte—and, so far as the writer is aware, they have not been successfully controverted in any material points—the clearness, simplicity, and cogency with which he presents even the most intricate phenomena and principles of vision are remarkable. Unlike many other treatises on subjects admitting of a strictly mathematical presentation, such as is given in most treatises on optics, Le Conte abstains as much as possible from the introduction of mathematical formulæ, which are after all only the graphic expression of truths or principles that can be formulated in words; even though the exact quantitative relations require the mathematical form for their expression. Le Conte himself considers his work on vision as among the best and most important he has done.

Any detailed discussion of the points wherein Le Conte has modified or changed or added to the definitions and explanations of previous writers would be out of place here, but among the most prominent may be mentioned his explanation of stereoscopic vision in connection with the true theory of binocular perspective; of the true nature of the horopter; the demonstration of certain fundamental physical phenomena in binocular vision, and the devising of a new mode of diagrammatic representation based thereupon. Also the explanation, for the first time, of certain peculiarities of phantom planes.

In the book "Outlines of the Comparative Physiology and Morphology of Animals," Le Conte's point of view of broad culture as the proper precursor to specialization and minute analysis is prominently exemplified. The book, which embodies

much of his other biological work, represents what might be called his as well as his students' favorite course, the one which more than any other attracted his audience and which, so far from discouraging concurrent or subsequent detailed work on their part, served conspicuously to attract students to special higher courses by the lively interest created in their minds—interest such as setting them down at once to a dissecting-table or museum case would never have brought about or sustained. The bearing of their subjects of study upon familiar living, moving objects and their correlations is ever that which interests pupils most, from childhood to maturity, and such interest is the best basis for earnest effort and success. The book serves admirably to avoid "the serious danger that . . . in microscopic clearness but narrowness of our knowledge we lose that general view of the whole, which alone gives significance to *any* knowledge."

The method of treatment also is peculiarly well adapted to the sustaining of interest throughout. Instead of the iron-clad academic consistency which has led some of our text-book writers in botany, for instance, to begin with the nearly invisible microscopic domain of unicellular organisms, because of the simplicity of structure, Le Conte throughout begins with the best-known though most complex form—man—and then uses the simplifications found in descending to the lower organisms to elucidate the complex structures and functions in the higher animals, for each organ or functional complex. This method may not conform to the latest doctrines in the matter of instruction, but it was notably and conspicuously successful in accomplishing the essential prime objects of all instruction. The interest was increased by the final summary of evolutional development in the subject of each chapter or functional subdivision. Just as the evolutional idea when broached by Darwin brought about a quick revival of interest where previously there had been fatigue from the multitude of dead, dissociated facts accumulated by investigators in the biological sciences, so the same idea is most fruitful in creating and fostering the interest of pupils under instruction in universities or even high schools.

As is natural, the subjects of sight and of the glycogenic functions of the liver, on which Le Conte had made special investi-

gations, are given great prominence, and the presentation of the subject first named is perhaps the most lucid and cogent that can be given within the space allowed by the plan of the book. The discussion of the kidneys and liver and their functions, in the chapter on "Katabolism," are among the most interesting in their suggestiveness. There is manifest throughout an evident relish of the subject, traceable to his "first love" in studying under Agassiz.

C. Philosophical Writings.

As may be seen from the list of his writings given at the end of this memoir, Le Conte dwelt and wrote frequently, almost throughout his life, upon philosophical subjects. These writings he fortunately gathered into permanent forms in later years, so that his views may be considered as quite fully represented in them. It would be of interest to follow through those papers the gradual development and change of his ideas in this direction; but to do so lies beyond the scope of this memoir. In his two books, "Religion and Science," 1873 (reprinted in 1902), and "Evolution and its Relation to Religious Thought," 1888 (second edition, revised, 1892), Le Conte summarizes his discussions and views on these subjects, in which he felt the deepest interest. Hence an analysis of these books perhaps gives a better insight into his mental attitude than any other part of his works.

In these discussions he has, probably more than any other man, contributed toward the formation of a sane public sentiment, and to the removal of unfounded prejudices against the doctrine of evolution from the minds of well-meaning persons. His fundamental thesis and deep conviction was that, under a correct interpretation of both, there cannot be any contradiction between the Book of Nature and the Book of Revelation. His consistent vindication of the claims of our spiritual nature as against the materialistic doctrines secured for him, himself a scientist of distinction, a respectful hearing, where mere scholastic discussion or dogmatic assertion, indulged in about equally on both sides, produced little or no impression, thus leaving the conflicting opinions unchanged.

Of the two books mentioned, the last-named, in which the fruitful idea of evolution is the keynote, is doubtless the one

which, coming just at the right time, had the widest influence, evolution being then the topic foremost in the public mind, and the contested sign of the times. The former book, however, had rendered important service in preparing the ground for the subsequent discussion, the importance of which is evidenced by the publication of many magazine articles and several books by distinguished scholars, both in America and abroad.

The attitude taken by Le Conte in his book on "Religion and Science" may be thus summarized from his own diction:

The whole universe of space and time, the whole external world, is so much of the Divine thought as has been realized by the Divine will. The scientific study of nature not only cannot destroy, but does not even diminish, the mystery of existence; it only increases our sense of the awfulness and grandeur of its mystery.

Claiming the constant immanence of God in nature, and that nature itself is a divine revelation, and reveals also very clearly the close connection of the spirit of man with the animating principle of brutes, through this with the vital principle of plants, and through this, again, with the physical and chemical forces of nature, he claims that the general forces of nature are an effluence from the Divine Person; that this diffused Divine energy throughout all time individuated itself more and more, until finally it assumed complete individuality, or separate entity or personality, in man; that throughout all geological time spirit remained, as it were, in embryo, gradually developing within the womb of Nature until it came to birth in man, and became capable of independent life. This idea of complete spiritual individuality includes every other characteristic of man—self-consciousness, free will or free agency, moral nature, moral responsibility, immortality, which he considers convertible terms. Probation, he says, is the necessary result of man's free agency. External nature is a revelation of the Deity, but it is not so clear as to compel faith in all men; it is, however, so related to his nature that it becomes a touchstone of his moral character. It depends entirely upon the temper in which man approaches the study of nature, what his free will chooses to find there, whether he sees in it a living God or only a dead mechanism. The universality and invariability of law in every realm of nature, extending even

to the inner realm of consciousness, does not annihilate the free will of man; it only limits it to its legitimate domain.

The word "evolution" occurs repeatedly in this book, but without any special emphasis. As stated by himself, Le Conte was at that time and for a number of years afterward, only a "reluctant evolutionist," the result of his training under Louis Agassiz.

In "Evolution and its Relation to Religious Thought"* Le Conte enlarges upon the detail, illustrations, and proofs of the views given in the former book, but without materially changing his fundamental concepts. The first of the three parts of the book discusses evolution in general, followed by a chapter showing the fundamental rôle of Louis Agassiz in laying the basis of the doctrine, although refusing to follow it out to its necessary consequences. Part second deals with the evidences of the truth of evolution, with a wealth of illustrative examples, presenting again the three series mentioned in earlier papers, viz., the natural-history series, the embryonic or ontogenic series, and the geological or paleontological series, each in their most forcibly convincing features; laying great stress upon the light shed on the entire subject by geographical distribution. These presentations of facts are preliminary to the third part of the book, which treats more directly of the "Relation of Evolution to Religious Thought."

Recognizing that the actual effect on human life is, or ought to be, an important element in our estimate of the truth of any doctrine, Le Conte states as postulates three processes—the cognition of external phenomena through the senses; the elaboration of these facts by the intellect, constituting knowledge; and the outgoing of this knowledge into the world as right or wise conduct. All three are equally important and necessary. Scientific workers are apt to consider only the first and second as necessary; metaphysicians only the second and third. From these omissions arises largely the so-called conflict between religion and science. In disregard of the first postulate, the cry of "wolf" has been raised at the enunciation of each one of the fundamental laws of nature now universally recognized. It has been so likewise with the law of evolution, and the alarm has

* The writing of this book was originally suggested to Le Conte by Henry Ward Beecher.

been proved as groundless as in the other cases. Evolution according to law has no bearing upon materialism, any more than has the law of gravitation; it simply defines the *manner* in which contrary to preconceived notions, the development of nature has actually occurred. The bar to the speedy settlement of this conflict is pride of opinion, self-conceit, dogmatism. The last is not merely on the theological side; modern materialism has outdone the theologian in this respect; but the theologian will of necessity have to change his base so as no longer to pin essential religious truth to unessential, merely dogmatic traditions.

According to Le Conte's view, the phenomena of nature are naught else than objectified modes of divine thought; the forces of nature naught else than different forms of one omnipresent divine energy or will; the laws of nature naught else than the regular modes of operation of the divine will, invariable because God is unchangeable. Science is the systematic knowledge of these divine thoughts and ways—a system of natural theology. According to this view, there is no real efficient force but spirit, and no real independent existence but God.

"It may indeed be that we cannot live and work in the constantly realized presence of the Infinite; that in our practical life and scientific work we shall continue to think of natural forces as efficient agents; but this attitude of mind, like our work-clothes, must be put aside when we return home to our inner, higher life, religious and philosophical."

Le Conte proceeds to enforce and illustrate this view quite elaborately, coming back to and vindicating the somewhat discredited term "vital force," or principle, as fully justified by its representing a distinct form of force.

"Nature, through the whole geological history of the earth, was gestative mother of the spirit, which, after its long embryonic development, came to birth and independent life and immortality in man. . . . Without spirit-immortality this beautiful cosmos, which has been developing into increasing beauty for so many millions of years, when its evolution is completed, would be precisely as if it never had been, an idiot tale signifying nothing. . . . If man's spirit were made out-of-hand, why all this elaborate preparation by evolution of the organic kingdom?"

Answering the objection that the views advanced imply panthe-

ism, Le Conte says that this can only happen through the one-sided pursuit of purely scientific or material lines of reasoning, as against the spiritual. No one can form a clear conception as to how immanence of the Deity in nature is consistent with a divine personality; yet we must accept both, because we are irresistibly led to each of these by different lines of thought. We must accept immanence without pantheism, and personality without anthropomorphism. Our own self-conscious personality behind brain phenomena compels us to accept consciousness, will, thought, personality behind nature. By a necessary law of thought this concept gradually expands without limit, until it reaches the thought of an Infinite Person. Just as in the case of time and space, we are compelled to recognize, without understanding, their illimitableness.

In discussing the two views of man's relation to nature—the one, that he alone, having an immortal spirit, is immeasurably removed from the animal world; the other, that he is merely the highest member of the order of primates, which includes the apes—Le Conte admits the measurable justification of both, the first from the psychical, the second from the structural point of view; the two views are not irreconcilable. Observing physical and chemical brain-changes, no matter how closely associated with mental or even localized activities, we are still as remote as ever from knowing *how* such changes bring about consciousness, thought, emotion. There is doubtless a relation between physical and psychic phenomena, but not in the same sense in which we use these terms in physical science. And we cannot bridge the gap between the animal and man without in the end logically attributing an immortal spirit to plants also and incurring a *reductio ad absurdum*. Le Conte believes that the spirit of man was developed out of the *anima* or conscious principle of animals, and this again out of the lower forms of life-force, and this in its turn out of the physical and chemical forces of nature; and that at a certain stage in this development, viz., with man, it acquired the property of immortality, precisely as now, in the individual history of each man, it progressively acquires the capacity of abstract thought. This rise to a higher plane he manifestly considers as occurring somewhat like the "mutations" now well known and accredited, and also quite unexplained.

"With every new birth of the universal energy into a higher plane, there appear new, unexpected, and to previous experience wholly unimaginable properties and powers. Why may not immortality be one of these?"

It is evident that the idea of a causal nexus between successive phenomena is a primary conception, and therefore ineradicable and certain. In childhood and in the uncultured races, external forces take the form of a personal will residing in each object (fetichism). The next form is that of several personal wills controlling each the phenomena of a different department of nature (polytheism). Finally, in the highest stage of culture, it takes the form of one personal will controlling the phenomena of the whole cosmos (monotheism), anthropomorphic to the unscientific mind. "But anthropomorphism has been driven from one department to the other by science and evolution, and to those folowing this line of thought alone, the phenomena of nature are relegated to forces inherent in matter, and the material forces are made to invade even the realm of consciousness and reduce this also to material laws. But a rational philosophy admits these two antithetic views and strives to reconcile and combine them. This reconciliation, so far as it is possible for us, is found *in a personal will immanent in nature and determining directly all its phenomena.*"

The idea of the *causal* nexus also determines that of *design;* adaptation of means to ends is in our experience the result of thought, and we cannot conceive it to result otherwise. It is impossible to conceive of adaptive structure without assuming intelligence as the cause. The effect of science cannot be to destroy this primary conception, which is ineradicable, but can only exalt and purify our conceptions of the Designer.

Le Conte finally considers the relation of evolution to the problem of evil. External, physical evil prevails throughout the animal kingdom, as evidenced in the struggle for existence. It is there a condition of effective evolution, and might be considered a good in disguise. But organic evolution, completed in man, was transferred to a higher plane, and continues as social evolution. Unconscious material evolution according to necessary law is transformed into psychical evolution, a conscious voluntary progress toward a recognized goal and according to a

freer law. But the fundamental conditions of evolution have not changed; man is surrounded on every side with what at first seems to him an evil natural environment, against which he must ever struggle, or perish. What is the only conceivable remedy? It is knowledge of the laws of nature, and thereby acquisition of power over nature. But increasing knowledge and power mean progressive elevation in the scale of psychical being also. The evil of physical disease can also be controlled by knowledge, the achievement of which also serves to elevate the plane of the mind. Thus, altogether, may we not generalize and say that physical evil is good in its general effect?

As to moral evil, the case is not so clear. Yet the course of human development, whether individual or racial, is from *innocence*, a pre-established harmony of spiritual activities, to *virtue*, self-established, through more or less discord and conflict. Here again, knowledge of the laws of God and obedience thereto is the remedy—the will to know and the effort to obey them. We cannot conceive of a moral being without freedom to choose; we cannot conceive of virtue without a successful conflict with solicitations to debasement. It is because these solicitations are so strong, and often overcome us, that we regard these themselves as essential evil, instead of our weak surrender to them. All evil consists in the dominance of the lower over the higher. True virtue consists, not in the ertirpation of the lower, which means asceticism, but in its subjection to the higher, for the higher is nourished by its connection with the more robust lower; and the lower is purified, refined, and glorified by its connection with the diviner higher, and by this mutual connection the whole plane of being is elevated. It is only by action and reaction of all parts of our complex nature that true virtue is attained.

Le Conte's early view of the older methods of metaphysics, formed as the result of reading many philosophical books, may be thus formulated: "Metaphysics ever strives after ultimate truth, which is unattainable, and of course fails . . . deludes us with promises of absolute knowledge, food for the gods; cheats us with gilded apples full of ashes. It is indeed only mental activity, and will continue to be so until scientific methods are adopted by metaphysicians."

It will be seen, however, that later he abated somewhat the

rigor of his disapproval and actively participated in the discussions of noted metaphysicians. These discussions were largely oral, and occurred in the meetings of the Philosophical Union at the University of California; a limited number of them passed into print in permanent form. Among these the most interesting is the book containing the discussion between Royce, Howison, Le Conte, and Mezes on "The Conception of God." Le Conte's latest (printed, but not published) discussion is a paper entitled "Evolutional Idealism," giving his view of the relations between God, nature, and man, and his conception of the ether as the substratum upon which the human spirit is developed, and from which, after death, may be derived the spiritual body, which he postulates as the condition of *personal* immortality and without which a perceptionless spirit—mere disembodied thought without personality—would seem to be offered us. There appear from this to be three kinds of "substance"—gross matter, ethereal matter or ether, and energy, *i. e.*, spirit. The ether is indissolubly associated with all forms of energy, such as light, electricity, heat, chemism. Life is a form of energy, so the ether is also the life-bearer. Now spirit is just essential energy itself, and therefore the ether must be associated with spirit; so it is also the spirit-bearer. Life and spirit differ from all lower forms of energy in being individuated, *i. e.*, endowed with self-activity. All three substances are progressively individuated in evolution: Energy completely individuated is created spirit; the ether, the energy-bearer, individuated, would be the ethereal (or spiritual) body; gross matter, as external vestment or habitation, is individuated into the live material body. The latter completes its organization in animals; but the ethereal body completes its organization only in man, *pari passu* with the individuation of spirit.

The material body is the matrix for the organization of the ethereal one; the brain seems to be the womb in which the ether becomes organized into the ethereal body. This organization, however, remains incomplete until, in man, the coöperation of self consciousness and free will begins.

"All this," he adds, "may seem but a sort of refined materialism. Not so. On the contrary, it is consistent with the most thoroughgoing idealism, for both gross matter and the ether are

but manifestations of the Divine Spirit in the self-conditioning forms of his consciousness called time and space—are but different grades of a downward effluence from the Divine Person; an effluence which again rises, by progressive organization in connection with the corresponding individuation of a finite portion of Divine Energy, to the plane of the spirit from which it came. The whole universe of created being is thus an evolutional series, every term of which is a form of the energy of SPIRIT."

Howison* comments thus, in part, upon the "Evolutional Idealism" of Le Conte, as set forth in the preceding abstracts:

"I confess that by the lucid force of Dr. Le Conte's reasonings and the great beauty of his conclusions I am constantly tempted to yield him my entire assent. It is only by the low murmurs of half-suppressed conviction that I am roused from this state of fascination to take up again the task of rigid thought. But . . . I will say that the stability of his system depends, I think, upon two things: First, whether it supplies sufficient proof that the Immanent Energy which is the cause of evolution is indeed a Cosmic Consciousness; second, whether, if real, having—as it must have—the attribute of immanence in nature, it is compatible with the freedom and the personal immortality at which the system aims." In discussing these two points, Howison further says: "As regards the first of these questions, I feel bound to say that the proof offered for the Cosmic Consciousness seems to me insufficient," going on to state his reasons for this opinion. On the second question, he says: "I cannot see how a Cosmic Consciousness, with its intrinsic immanence in nature, can be reconciled with true freedom at all; and its consistency with an immortality truly personal is to me beset with obscure alternatives, between which either the certainty or else the value of the life to come vanishes away."

Both these positions are extendedly argued by Howison in the sequel, and still farther in the volume of essays separately published by him under the general title "The Limits of Evolution." In the first of these he dwells with special emphasis upon the "unbridgeable gaps" which, he claims, exist between inorganic and organic nature and between the natural and spiritual

*The Conception of God, p. 115.

worlds, interrupting the continuity of evolution; and he undertakes to show that there is a farther break between physiological and logical genesis.

Royce says: "I must frankly confess that . . . I have never been able to give to this doctrine (of evolution), justly central as it is in the world of recent empirical science, the far-reaching, the philosophical, the universal significance which Le Conte still attributes to this aspect of reality. Evolution is, to me, not a process in the light of which we can learn much either concerning the Absolute, or concerning the relation of the eternal to the temporal world."

It is, of course, beyond the province of this memoir to attempt the settlement of such an issue as this between Le Conte and these critics, whom he himself considered well qualified for their task. Le Conte at all events was in no wise disconcerted by their contentions. In the introduction to "The Conception of God" he authorized the editor to say, in his behalf, that he "came out of the whole discussion, with its objections to his own system on all hands, without feeling that he must retract or materially alter the propositions which give it a distinguishing character." The writer of this memoir may add that in conversation with him, Le Conte repeatedly said that in the farther coöperative progress of science and philosophy, the alleged gaps would be sure to disappear.

LE CONTE'S OWN ESTIMATE OF HIS LIFE-WORK.

In concluding his autobiography, Le Conte gives the following summary estimate of his life-work:

"And now, looking back on a long life of incessant activity, what have I done of value to the world? what have I added to human thought? what influences for good may I hope to leave behind me?

"I. In science, touching only the most important points:

"(*a*) My paper in 1859 on 'The Correlation of Physical, Chemical and Vital Force' gave, I think, both impulse and greater definiteness to scientific thought on that subject. Carpenter in the last edition of his Physiology gives me credit for a distinct advance in this subject.

"(*b*) My researches on the phenomena of binocular vision I

am sure did clear up thought in this field. I claim, and have generally been accorded, the credit of several original thoughts, which have remained a permanent possession of science: (1) The demonstration of the real nature of the Horopter; (2) the demonstration of the true nature of the theory of binocular perspective; (3) the demonstration of certain fundamental physical phenomena in binocular vision, and the devising of a new mode of diagrammatic representation based thereon. These phenomena had been observed by some, but not understood; their explanation had been hinted at by others, but not clearly brought out: (4) the explanation, for the first time, of certain peculiarities of phantom planes.

"(*c*) In geology, I believe some real, substantial advance was made in my series of papers (1) on the structure and origin of mountain ranges; (2) on the genesis of metalliferous veins; (3) especially in that on critical periods in the history of the earth; (4) on the demonstration of the Ozarkian or, better, the Sierran epoch as one of great importance in the history of the earth. I might mention several others that are of prime importance, but I am willing to stand by these.*

"(*d*) In biology, my views on glycogeny, although not yet certain, have undoubtedly contributed to clearness of scientific thought on that important subject.

"II. In philosophy:

"I look back with especial pleasure on my writings on evolution. I lay no claim to the discovery of new facts bearing on the theory of evolution, but only to have cleared up its nature and scope, and especially to have shown its true relations to religious thought. It is well to stop a moment to show the rôles of different thinkers in the advance of this subject. Leaving out of consideration mere vague philosophic speculations, like those of the ancient philosophers, and of Swedenborg in more modern times, I would say that the rôle of Lamarck was to introduce evolution as a scientific theory; that of Darwin, to present the theory in

*Le Conte's omission to mention in the above list his important exploration and delimitation of the "Great Lava Flood of the Northwest" and the "Structure and Age of the Cascade Mountains" is characteristic of his slight regard for mere detail work as against the philosophical discussions and conclusions based thereon.

such wise as to make it acceptable to and accepted by the scientific mind; that of Huxley, to fight the battles of evolution and to win its acceptance by the intelligent popular mind; that of Spencer, to generalize it into a universal law of nature, thus making it a philosophy as well as a scientific theory. Finally it was left to American thinkers to show that a materialistic implication is unwarranted; that evolution is entirely consistent with a rational theism and with other fundamental religious beliefs. My own work has been chiefly in this direction. In my lectures in 1872 on 'Religion and Science' I might be called a reluctant evolutionist; yet even then, in the sixteenth chapter of the book, I tried to show the mode of origin of the spirit of man from the psyche of animals by a process of evolution. In a few years, however, I was an evolutionist, thorough and enthusiastic. Enthusiastic not only because it is true, and all truth is the image of God in the human reason, but also because of all laws of nature it is by far the most religious—that is, in accord with religious philosophic thought. It is, indeed, great tidings of joy which shall be to all peoples. Woe is me if I preach not the gospel! Literally, it can be shown that all the apparently irreligious and materialistic implications of science are reversed by this last child of science, or rather this daughter of the marriage of science and philosophy. During all my life I have striven earnestly to show this; my book on 'Evolution and Its Relation to Religious Thought' is the embodiment of the result of these strivings, although I believe that if I wrote it again I could add much to the argument. I began this line of thought in 1871, and believe, and therefore claim, that I was the pioneer in the reaction against the materialistic and irreligious implication of the doctrine of evolution. I look with greater pleasure on this than on anything else that I have done. At first I suffered some, but not much, obloquy on the part of the extreme orthodox people; but I have lived to see this pass away, and all intelligent clergymen coming to my position.

"All, or nearly all, of my philosophic writings are more or less connected with the doctrine of evolution, and I regard these as among the most important of my writings. Indeed, one of my friends thinks that the best and most permanent that I have done is in the domain of philosophy rather than in that of sci-

ence proper. But he is a philosopher; perhaps my scientific friends think differently."

It would be of interest to quote, as corollaries to Le Conte's estimate of his own work, given above, from some of the numerous obituary articles published in magazines and periodicals shortly after his death; but to do so would exceed the limits of this memoir. Among them may be specially mentioned those written by several of his colleagues: Professors T. R. Bacon,* S. B. Christy,† A. C. Lawson,* and J. C. Merriam;* Chas. M. Bakewell,* of Yale, and Josiah Royce,‡ of Harvard. That of the latter, formerly Le Conte's pupil, is one of the most interesting and is in part as follows:

"His wealth of knowledge, his instinct for order and lucidity of reflection, have indeed always remained my hopelessly distant ideal. I believe in the world's unity, and by indirect proof feel sure of it; but the world of facts will never seem to my unaided thought as perfect and as clearly visible a union of the one and many of harmonious principles and of multitudinous empirical illustrations as it seemed to me while I listened to his lectures."

All these articles alike bear witness to Le Conte's intellectual greatness and the lovableness of his character.

Space forbids further quotations from others. The writer's own estimate,* written under the first impression of the news of Le Conte's death, summarizes the views still held by him:

"The death of Dr. Joseph Le Conte removes one of the foremost thinkers and scientific men of the time; one whose writings and modes of thought have influenced the progress of science, and of scientific as well as popular opinion, throughout the civilized world. He was prominent in the now fast-thinning ranks of those who, like Louis Agassiz, J. D. Dana, and Asa Gray, in the New, and Lyell, Oersted, Darwin, and Wallace, in the Old World, thought and found it not only possible, but necessary, to be something more than specialists in one domain of science, in order to understand its full meanings and bearings upon other branches and its place in the world-plan. Le Conte never

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*University of California Magazine, September, 1901.

†Trans. Am. Inst. of Mining Engineers, Mexican meeting, November, 1901.

‡International Monthly, September, 1901.

doubted the existence of such a plan, and he looked upon nature reverently as one part of its manifestations; but without undervaluing for a moment the other, the spiritual part, which is now so commonly cast aside as a mere 'property of matter in an advanced state of evolution;' while, on the other hand, there are still those who claim to evolve its nature from their inner consciousness, independently of observed phenomena. Le Conte's early education and experience as a physician laid the foundations of the broad knowledge which later made him equally at home in the purely physical sciences and in the biological field. While his geological writings are, perhaps, best known to the American public through the wide use made of his books on that subject, both in universities and in the secondary schools, his early and warm advocacy of the doctrine of evolution has probably served most to make him known and appreciated in the Old World, where he was warmly welcomed and honored in scientific assemblies, among the foremost men.

"It is sometimes said that those who undertake to generalize in science are apt to be unable to make accurate observations themselves. While this is true in some cases, it was certainly otherwise in that of Le Conte. His scientific writings and special papers show an eminent capacity for close observation; yet his glance was always upon the bearings of what he saw, upon general problems rather than upon the minor details of each field of view, which he was quite content to leave to others. At the same time, he had the true scientific spirit, in the absence of all dogmatism and the readiness at all times to consider candidly any observations or opinions at variance with his previous conclusions. He considered the cultivation of the spirit of truthfulness, candor, and readiness to revise one's opinions and conclusions as constituting one of the strongest claims of natural science as an educational factor, in contradistinction to the acceptance of mere opinions and precedents that is so common a result of exclusive literary and philosophical study. The personal gentleness for which he was so well known and beloved was deeply grounded in the absence of any claim to infallibility for himself.

"It is not easy to overestimate the influence he has exerted in rectifying the popular idea that the doctrine of evolution

necessarily tends to materialism, if not atheism—a misconception of its true import which is unfortunately still shared by the extremists both on the scientific and religious side.

"As shown above in the discussion of his philosophical views, Le Conte held that, so far from this, it inculcates the highest ideal of an intelligent world-plan; and he staunchly maintained not only its compatibility with Christian religious belief, but that, by elevating nature into the realm of teleologic thought and aspiration, it offers a much higher point of view than could be derived from any of the 'orthodox' views of the method of creation. This part of his influence will, perhaps, be most missed in the present state and tendency of scientific thought; particularly among the younger men of science, whose eagerness to specialize prematurely almost inevitably tends to prevent such catholicity of views and encyclopedic knowledge as characterized Dr. Le Conte.

"It was Le Conte through whom the University of California first became known to the outside world as a school and center of science on the western border of the continent; and for a number of years he almost alone kept it in view of the world of science. His presence and connection with the University was largely instrumental in attracting to it other men who otherwise would have hesitated to emigrate from their eastern homes to what was then the outskirts of civilization; and his ceaseless scientific activity acted as a strong stimulus both to his colleagues and to the students coming under his instruction, whose affection and esteem remained with him through life. He preferred this kind of activity to the more ambitious prospects that were many times open to him; he shrank from anything that would force him from the ideal world in which he lived into active contact with executive or administrative functions. His modesty and simplicity survived, unscathed, the applause and laudations bestowed upon him, and his strong will and cheerful disposition carried him up to a mature age in undiminished mental vigor, despite an apparently frail body.

"His death brings heavy loss to his university and to the world of thought at large, in which he occupied so high and exceptional a position."

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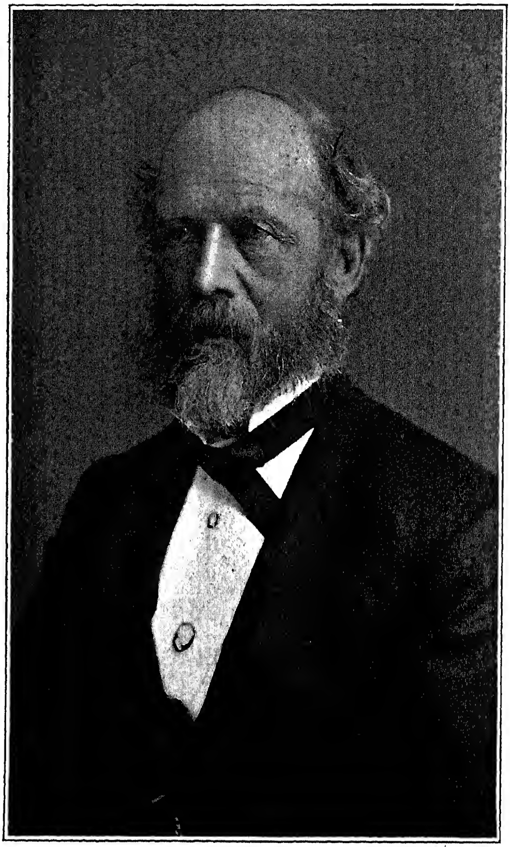

L H Morgan

BIOGRAPHICAL MEMOIR

OF

LEWIS HENRY MORGAN

1818-1881

BY

W. H. HOLMES

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
NOVEMBER 20, 1907.

BIOGRAPHICAL MEMOIR OF LEWIS HENRY MORGAN.

LEWIS HENRY MORGAN, lawyer, statesman, and ethnologist, was born in Aurora, New York, November 21, 1818, of distinguished New England ancestry, numerous members of his family having held places of trust in the community and state. His father was Jeremiah Morgan and his mother Harriet Steele. He was graduated from Union College in 1840, and received the degree of LL.D. from that institution in 1875. In 1851 he was married to his cousin, Miss Mary A. Steele, of Albany. Shortly after his graduation he was admitted to the bar in Rochester, where he formed a partnership with George F. Danforth, afterward judge of the Court of Appeals. In 1855 he became associated as legal adviser with a railroad in course of construction between Marquette, Michigan, and the Lake Superior iron region, and for a few years found it necessary to spend much of his time in the West. Later he was able in a measure to devote his energies to political affairs, and was elected to the New York State Assembly in 1861, and to the Senate in 1868.

It was Morgan's achievements as an ethnologist, however, that brought to him permanent fame and finally gave him his position in the world of science, which was signalized by admission to the National Academy of Sciences in 1875. The circumstances which led to his interest in ethnology are worthy of record and serve to illustrate the character and tastes of the man. As a member of a secret society called "The Gordian Knot," shortly after admission to the bar in Rochester, in 1840, he became closely associated with Ely S. Parker, a Seneca Indian, who came from Tonawanda to Rochester to complete his education and who acquired prominence during the Civil War as a member of General Grant's staff, and later as Commissioner of Indian Affairs. Through his association with Parker, Morgan conceived the idea of organizing The Gordian Knot on the basis of the League of the Iroquois, and a study of this re-

markable institution followed. The society in its new form was known to the public as "The Grand Order of the Iroquois," but for its members had the title We-yo-ba-yo-de-za-de Na-bo-dé-no-sau-nee, "They who live in the home of the dwellers in the long house."* The scheme was launched with much enthusiasm and the organization became popular for a time throughout western New York, but it met with slight response on the part of the Indians.

It was the chief purpose of Morgan and his associates to devote the energies of the new society to the study and perpetuation of Indian lore, the education of the Indian tribes, and the reconciliation of these tribes with the conditions imposed by civilization. The most important result of the movement, however, was the insight acquired by Morgan into Iroquois institutions, thus laying the foundation of his epoch-making investigations among the American tribes as well as in the wider field of world anthropology. His intimacy with these people was much enhanced by an event which may be mentioned in this place. A certain land company had secured pre-emptive rights to purchase the lands of the Indian reservations in New York whenever the Indians should be willing to sell, and a treaty confirming this agreement was before the United States Senate for ratification. The disastrous effect on the future of the tribes of the establishment of this claim was realized by the society, and, with a view of defeating the measure, Morgan was sent to Washington, where he met with entire success in his mission. He thus became widely known and exceedingly popular among the tribes, and on October 1, 1847, was adopted into the Hawk clan of the Seneca nation as the Son of Jimmy Johnson, "So-se-ba-wa," receiving the name of Ta-ya-da-o-wub-kub, or "One Lying Across"—that is, a bridge or bond of union between the Indians and the white men.† He now found himself admitted to the innermost circles of native society, and, once there, he embraced every opportunity to pursue his investigations. Between 1844 and 1846 various papers

* Porter, in League of the Iroquois, edition of 1904, Vol. II, p. 155, Appendix B.

† Lloyd, League of the Iroquois, p. 163.

embodying the results of his researches among the Senecas were read before the councils of the newly organized society, and, amplified and rearranged, were published, under the title of "Letters on the Iroquois," in *The American Review.* In 1846 he read before the New York Historical Society an essay on "The Constitutional Government of the Six Nations of Indians," embodying much of the matter contained in the Letters; and in 1848 reprinted eleven of the Letters in *The Olden Time,* an antiquarian magazine published in Pittsburg. In 1849 the New York State University made an appropriation for the enlargement of its Indian collection, and entrusted the execution of the resolution to Morgan, who submitted a report of much interest, which is indispensable to an understanding of the various Iroquoian artifacts of that period. Finally the materials thus accumulated, along with some new matter relating to the customs and beliefs of the Indians, appeared as "The League of the Iroquois," which Powell refers to as "the first scientific account of an Indian tribe ever given to the world," and which is justly estimated by Lloyd as entitling Morgan to the name of "Father of American Anthropology." The dedication reads: "To Hasa-no-dú-da, Ely S. Parker, a Seneca Indian, this work, the materials of which are the fruits of our joint researches, is inscribed in acknowledgment of the obligations and in testimony of the friendship of the author."

In 1856, while still engaged in the practice of law, Morgan read a paper before the Albany meeting of the American Association for the Advancement of Science, on "The Laws of Descent of the Iroquois," which excited so much interest that he decided to turn again actively to ethnological pursuits.

While at Marquette on business connected with his railroad interests (1858), he became acquainted with an encampment of the Ojibwa Indians, belonging to the Algonquian family, and hence distinct in language from the Iroquois, and soon learned that the kinship system of these people corresponded closely with that of the tribes of the League. This was unexpected, as he had reached the conclusion that the Iroquois system was probably unique. He was thus led to the study of other tribes, and for a number of years pursued his investigations in various

sections of the country, extending his journeys to Kansas, Nebraska, the upper Missouri, Lake Winnipeg, and the Hudson Bay Territory. In the end he had brought together the systems of relationship of upward of seventy Indian tribes, speaking as many independent dialects. The final conclusion reached was, that the kinship system of the Iroquois was practically that of the aborigines of the continent.* Seeking to enlarge his field of observation still further, schedules intended for recording the kinship of the tribes were widely distributed, and his researches thus extended to the primitive world in general. The materials collected through the medium of an extensive correspondence were classified and finally published by the Smithsonian Institution as volume XVII of its Contributions to Knowledge, entitled "Systems of Consanguinity and Affinity of the Human Family" (1871). It is a quarto volume of about six hundred pages, and constitutes a model of inductive research, embodying a record of the kinship systems of eighty tribes of North America, together with those of a great number of the principal nations and tribes of the Old World and the islands of the Pacific.

"This publication," says Powell, "marks a most important epoch in anthropologic research. Prior to its appearance the social and governmental institutions of mankind antecedent to the evolution of civilization were to a large extent unknown Travelers and various persons more or less familiar with tribal life had put on record many curious facts, and the compilation of these facts by scholars had resulted in the accumulation of incoherent and inconsistent materials, about which more or less crude and fanciful speculations were made; but the essential characteristics of tribal society, as based upon kinship in barbarism and upon communal marriage in savagery, were unknown."†

Morgan's researches at this period were, however, not restricted to the study of the human subject. While in the West

* Conjectural Solution of the Origin of the Classificatory System of Relationship. *Proc. Am. Acad. of Arts and Sciences.* Vol. VII, February, 1868.

† *Popular Science Monthly*, Vol. VIII, p. 117.

on business connected with railroad enterprises, he became interested in the habits of the beaver, and in 1868 published a volume entitled "The American Beaver and His Works." The extensive series of observations embodied in this work were begun while he was engaged in trout fishing in the wilds of Michigan. The following paragraph is from his preface:

"Our course, in passing up and down, was obstructed by beaver-dams at short intervals, from two to three feet high, over which we were compelled to draw our boat. Their numbers and magnitude could not fail to surprise as well as interest any observer. Although constructed in the solitude of the wilderness, where the forces of nature were still actively at work, it was evident that they had existed and been maintained for centuries by the permanent impression produced upon the rugged features of the country. The results of the persevering labors of the beaver were suggestive of human industry. The streams were bordered continuously with beaver meadows, formed by overflows by means of these dams, which had destroyed the timber upon the adjacent lands. Fallen trees, excavated canals, lodges, and burrows filled up the measure of their works. These together seemed to me to afford a much greater promise of pleasure than could be gained with the fish-pole, and very soon, accordingly, the beaver was substituted for the trout. I took up the subject, as I did fishing, for summer recreation. In the year 1861 I had occasion to visit the Red River settlement in the Hudson's Bay Territory, and in 1862 to ascend the Missouri River to the Rocky Mountains,—which enabled me to compare the works of the beaver in these localities with those on Lake Superior. At the outset I had no expectation of following up the subject year after year, but was led on by the interest it awakened, until the materials collected seemed to be worth arranging for publication. Whether this last surmise is well or ill founded, I am at least certain that no other animal will be allowed to entrap the unambitious author so completely as he confesses himself to have been by the beaver."

The time had now come for Morgan to extend his investigations to other branches of research relating to the aborigines. The social organization, especially the kinship system, appeared

to him to have exercised a pronounced influence on the customs and arts of the peoples, and notably on their domestic architecture. The study of this subject led to the preparation of a series of articles entitled "The Seven Cities of Cibola," which appear in *The North American Review* for 1869. In these articles strong arguments are advanced to show that the great ancient pueblo structures of New Mexico and Arizona, as well as those of Mexico, were not the palaces of princes and potentates, but merely communal dwellings of exceptionally advanced tribes, and that their construction was due to the prevalence of a system of relationships identical with that observed among the tribes of the North. A long step was thus taken toward the removal of the misinterpretations and exaggerations of the Spanish historians and toward a proper understanding of the remarkable culture of the ancient Mexicans.

The subject of migrations of the tribes next engaged his attention, and in 1869 two articles appeared in the above-mentioned journal, in which the idea was promulgated that the great valley of the Columbia River had been, on account of its vast natural food resources, a cradle of the tribes, and that from this valley the overflow of population passed out to the south and east, to occupy the plains and valleys.

Turning his attention again to the semi-civilized nations of Mexico, Morgan published a most noteworthy article entitled "Montezuma's Dinner," in which he placed his own conception of this event in strong contrast with that of H. H. Bancroft, who had followed the highly imaginative accounts of the Spanish conquerors. It was shown that, stripped of manifest exaggeration, the dinner was the comparatively simple repast of a great elective war chief, and not that of an absolute monarch or potentate. This paper was followed a little later by one on "The Houses of the Mound Builders," in which the author essays to reconstruct the habitations of these people in accordance with his conception of the necessary architectural accompaniment of the system of relationships found among existing tribes.

The time had now come for Morgan, whose mind passed readily from details to generalizations, to bring together the results of his investigations of tribal society in a single treatise.

This was accomplished in his epoch-making volume entitled "Ancient Society," published in 1877 and reissued in the following year. The work was dedicated to the Rev. J. H. MacIlvaine, late professor of belles-lettres in Princeton College, who had been a close friend and adviser of Morgan for many years, and who pronounced an able eulogy on the occasion of his funeral, cited at length in the League of the Iroquois, edition of 1904, page 167.

The treatise on Ancient Society was divided into four parts, as follows: Part I, Growth of intelligence through inventions and discoveries; Part II, Growth of the idea of government; Part III, Growth of the idea of the family; and Part IV, Growth of the idea of property. In Part I a comprehensive view of the evolution of culture is given, and the phenomena are classified and subdivided in a manner exceedingly helpful to the historian of the race. In introducing the subject Morgan employs the following words:

"As we re-ascend along the several lines of progress toward the primitive ages of mankind, and eliminate one after the other, in the order in which they appeared, inventions and discoveries on the one hand, and institutions on the other, we are enabled to perceive that the former stand to each other in progressive and the latter in unfolding relations. While the former class have had a connection, more or less direct, the latter have been developed from a few primary germs of thought. Modern institutions plant their roots in the period of barbarism, into which their germs were transmitted from the previous period of savagery. They have had a lineal descent through the ages, with the streams of the blood, as well as a logical development. Two independent lines of investigation thus invite our attention The one leads through inventions and discoveries, and the other through primary institutions. With the knowledge gained therefrom, we may hope to indicate the principal stages of human development."

These stages, each of which represents a distinct culture and particular mode of life, beginning with the earliest, are: (1) Savagery, subdivided into the older, the middle, and the later; (2) barbarism, with three sub-periods—the older, the middle, and the later; and (3) civilization.

The arts of subsistence in their relation to the progressive steps of culture are discussed in this chapter. The steps as developed are: (1) "Natural subsistence upon fruits and roots in a restricted habitat," which is described as a strictly primitive condition preceding the utilization of fire. (2) "Fish subsistence," which implies the use of fire, by which means man became independent of climate and locality. (3) "Farinaceous subsistence, through cultivation." This begins with the cultivation of cereals, and in the western hemisphere marks the early stages of barbarism occupied by the great body of the tribes. (4) "Meat and milk subsistence." The domestication of animals, which was not achieved by the western world because of the absence of suitable species, but gave impetus to the development of old world peoples of the middle status. The possession of corn, however, by the Americans gave such a strong impetus to racial development that many of the tribes acquainted with this, the greatest of cereals, advanced into the middle stages of barbarism. (5) "Unlimited subsistence through field agriculture." This period, not reached by any of the American tribes, witnessed the domestication of animals and their employment in agricultural pursuits.

In Part II Morgan discusses the different forms of social and political organization in the order of their development, the first and lowest social grouping being based on sex relations. In this system certain established groups or classes of men have rights of mating with particular groups of women. Out of this form, which still survives among numerous peoples, gradually grew that of the organization of society on the basis of kinship, which form successively took on higher combinations in the gens, the phratry, and the confederacy, the latter among the Iroquois partaking of the nature of a purely political organization. Finally, he shows by illustrations from many sources how these groupings as constituted in the old world passed upward into modern civilized forms of political government. In this connection he undertakes to explain the change from descent in the female line, prevalent among primitive peoples, to descent in the male line, and the influence of property considerations in bringing this about.

In Part III the author treats of the history of the family, pointing out five successive stages in its development, and the manner in which the earlier forms passed upward into the Monogamian form now prevalent throughout most of the civilized world. The five forms are designated as follows:

1. The Consanguine;
2. The Punaluan;
3. The Syndyasmian;
4. The Patriarchal;
5. The Monogamian.

It is observed that Morgan does not assume that the earlier forms passed uniformly and as a whole into the higher forms, but that this order prevailed generally, each form taking on phases varying with the people and the period.

The *Consanguine* family was founded on the intermarriage of brothers and sisters, own and collateral, in a group, and is not now represented, save sporadically, among even the most primitive tribes; but numerous traces of this form are found in the succeeding system, the Punaluan, which is still to be found among many peoples, notably the tribes of India and the American aborigines.

The *Punaluan* form of the family follows the Consanguine, of which it was a modification. Its chief characteristics were the intermarriage of several sisters, own and collateral, with each others' husbands in a group, and of the intermarriage of several brothers, own and collateral, with each others' wives in a group. In each case a group of men were conjointly married to a group of women. This family has existed in Europe, Asia, and America within the historic period, and in Polynesia within the past century. It prevailed in savagery and the lower stages of barbarism, and among the Britons persisted until that people had reached the middle status of barbarism.

The *Syndyasmian* family was founded on marriage between single pairs but without exclusive relations, the marriage continuing only during the pleasure of the pairs. The pairing was a matter of convenience and arranged by the parents, more especially the mothers, with or without the consent of the contracting parties. Several pairs usually dwelt together, forming

one household in which the principle of communism in living was practiced. In this system we have the nucleus of the Monogamian family.

The *Patriarchal* family was founded on the marriage of one man with several wives and in general by the seclusion of the wives. The essential characteristic of this form was the organization of a number of persons, bond and free, into a family under paternal power for the purpose of holding lands and for the care of flocks and herds. In Morgan's words, this family "marks that peculiar epoch in human progress when the individuality of the person began to rise above the gens, in which it had previously been merged, craving an independent life and a wider field of individual action. Its general influence tended powerfully to the establishment of the Monogamian family, which was essential to the realization of the objects sought. * * * In the Consanguine and Punaluan families, paternal authority was impossible as well as unknown; under the Syndyasmian it began to appear as a feeble influence; but its growth steadily advanced as the family became more and more individualized, and became fully established under Monogamy, which assured the paternity of children."*

Although until recently it has been generally believed that the *Monogamian* family, the union of single pairs, was the fundamental and general form of the family, Morgan clearly shows that it did not come into existence until the advance-guard of human progress had achieved civilization and not until much later than this among the classical nations. With the Greeks the wives did not become the equals of the husbands in dignity, personal rights, and social position even during the period of their highest development. The Monogamian family, as finally constituted, has "assured the paternity of children, substituted individual ownership of real as well as personal property for joint ownership, and the exclusive inheritance by children in place of agnatic inheritance. Modern society reposes upon the Monogamian family. The whole previous experience or progress of mankind culminated and crystallized in this pre-eminent institution. It was a slow growth, planting its

* Ancient Society, 1877, p. 466.

roots far back in the period of savagery—a final result toward which the experience of the ages steadily tended. Although essentially modern, it is the product of a vast and varied experience."*

"We have a record of the Monogamian family running back nearly three thousand years, during which, it may be claimed, there has been a gradual but continuous improvement in its character. It is destined to progress still further, until the equality of the sexes is acknowledged and the equities of the marriage relation are completely recognized."†

Morgan's conception of the development of the family—the central idea in the social structure—is supported by a vast body of observations drawn from a multitude of sources, and although he must share with Tylor and others the honor of first entering this great unexplored field of research, he must be allowed the credit of going directly to original sources for his information and, after the accumulation of a great body of data, erecting therefrom a system which, although necessarily subject to many modifications as the result of more extended observations, must command respectful consideration on the part of all succeeding students of the evolution of social institutions.

Part IV deals with the evolution of property and its place in the history of culture. In beginning, the author outlines the whole scheme of culture development, presenting a comprehensive view of each branch of human activity and its relations with each other branch and with the whole, proceeding then to an analysis of the part taken by the idea of property in shaping the final result.

In early savage times the idea of property had hardly been conceived and personal possessions were exceedingly limited; on the death of the owner they are usually deposited with his body in the grave. Later, when the successive social groupings had culminated in the gens, such portions of property as were not buried with the dead were distributed to the members of the gens. Here we have the first known trace of regulated inheritance. Although the property left was probably as

* Ancient Society, 1877, p. 505.

† Ibid., p. 390.

a rule appropriated by the nearest of kin, the principle was general that the property should remain in the gens of the decedent and be distributed among its members. Children inherited from their mother, to whose gens they always belonged, but took nothing from their father, since his identification was uncertain, and besides he belonged always to a gens other than that of the mother. His property on death reverted to his own gens.

In the early stages of barbarism this form of inheritance continued. "The variety and amount of property were greater than in savagery, but still not sufficient to develop a strong sentiment in relation to inheritance. In the mode of distribution may be recognized the germ of the second great rule of inheritance, which gave the property to the agnatic kindred, to the exclusion of the remaining gentiles. Agnation and agnatic kindred, as now defined, assume descent in the male line; but the persons included would be very different from those with descent in the female line. The principle is the same in both cases, and the terms seem as applicable in the one as in the other. With descent in the female line, the agnates are those persons who can trace their descent through females exclusively from the same common ancestor with the intestate; in the other case, who can trace their descent through males exclusively. It is the blood connection of persons within the gens by direct descent, in a given line, from the same common ancestor which lies at the foundation of agnatic relationship."*

In the middle status of barbarism progress in many branches of activity and the great increase in property gave the question of inheritance increasing importance. In the words of Morgan, "The territorial domain still belonged to the tribe in common; but a portion was now set apart for the support of the government, another for religious uses, and another and more important portion, that from which the people derived their subsistence, was divided among the several gentes, or communities of persons, who resided in the same pueblo" (*supra,* p. 200). "That any persons owned lands or houses in their own right, with power to sell and convey in fee-simple to whomsoever they

* Ancient Society, p. 531.

pleased, is not only unestablished but improbable. Their mode of owning their lands in common, by gentes, or by communities of persons, their joint-tenement houses, and their mode of occupation by related families precluded the individual ownership of houses or of lands. * * * The possessory right, which we must suppose existed in individuals or in families, was inalienable, except within the gens, and on the demise of the person would pass by inheritance to his or her gentile heirs."*

In higher barbarism, when property had still further increased and individual holdings became of importance, as in herds, flocks, houses, and lands in severalty, it was natural and inevitable that the husband's powers and pretensions should greatly increase; and, since at this stage the development of the family was such that the relation of father and children was readily established, a new order of inheritance would supervene, and on the decay of the clan system would readily pass to inheritance within the immediate family, and in its highest specialization to exclusive inheritance by whomsoever the decedent might name.

The following paragraph is exceptionally interesting as containing a prophecy of the final disposal of one of the dominant problems of civilization, the regulation of property holdings:

"Since the advent of civilization, the outgrowth of property has been so immense, its forms so diversified, its uses so expanding and its management so intelligent in the interests of its owners, that it has become, on the part of the people, an unmanageable power. The human mind stands bewildered in the presence of its own creation. The time will come, nevertheless, when human intelligence will rise to the mastery over property, and define the relations of the state to the property it protects, as well as the obligations and the limits of the rights of its owners. The interests of society are paramount to individual interests, and the two must be brought into just and harmonious relations. A mere property career is not the final destiny of mankind, if progress is to be the law of the future as it has been of the past. The time which has passed away since civilization began is but a fragment of the past duration of man's existence, and but a fragment of the ages yet to come. The dissolution of

* Ancient Society, p. 535.

society bids fair to become the termination of a career of which property is the end and aim, because such a career contains the elements of self-destruction. Democracy in government, brotherhood in society, equality in rights and privileges, and universal education foreshadow the next higher plane of society to which experience, intelligence, and knowledge are steadily tending. It will be a revival, in a higher form, of the liberty, equality, and fraternity of the ancient gentes."*

The last work of Morgan is his "Houses and House-life of the American Aborigines." It is dedicated to William W. Ely, M.D., LL.D., the cherished friend and literary adviser of the author for a period of more than twenty-five years, and was intended originally as the fifth and final chapter of "Ancient Society." It was omitted from that volume on account of its bulk, and finally made its appearance as volume IV of Contributions to North American Ethnology. The first chapter is a condensation of the four chapters of "Ancient Society," and reviews the history of the development of society as manifested in the gens, phratry, tribe, and confederacy—a knowledge of these organizations being indispensable to an understanding of the houses and house-life of the aborigines. The houses and house-life served in turn to illustrate and verify Morgan's conception of the organization of primitive society of the early and middle stages of barbarism.

Chapters II, III, and IV are devoted to the laws of hospitality, communism in living, and usages and customs with respect to land and food. It is shown that the universal practice of hospitality, as well as of communism in large households, determined in great measure the character of the houses and house-life. The remainder of the work is devoted to a detailed description and discussion of the houses of the tribes, especial attention being given the multiple-roomed structures which constitute the dominant feature in the building art of the tribes all over America.

Morgan was a man of exceptional mental endowments, and the passion for research developed early in his career knew no diminution to the end of his life. His tireless energy and great

* Ancient Society, p. 552.

tenacity of purpose are attested by the manner in which he pursued clues that by seeming accident were thrown in his way. Observing while hardly more than a schoolboy the peculiar family relationships of the Iroquois, he soon mastered the system in every detail, believing it to be peculiar to this people and unique in the world. Seizing the first opportunity to make inquiries among other and distant tribes, he found the same system of kinship prevailing. With increasing zeal and widening vision he extended his researches from tribe to tribe and from region to region, never halting until he had extended his observations over the entire primitive world. A study of these observations led to the remarkable conclusion that the social systems of all mankind have been cast in the same general mold; but it was found that the particular form of society observed among the Iroquois was confined largely to a single horizon of culture, and he found it necessary to widen again the scope of the inquiry. In investigating the one stage he had caught glimpses of earlier phases of social organization; and having, after prolonged research, formulated these, he delved into the literature of all nations, confirming thereby his notion of the earlier forms and extending his observations to higher planes of society as exemplified in civilization. He was thus able to stand on the horizon of the present, as represented by the highest levels of social achievement, and look backward through long vistas of human progress in which five successive stages of society were traceable, the earliest, dimly discernible in the remote distance, rising gradually into the next higher, and passing upward until the Monogamian system of the present was reached.

Morgan thus formulated for the first time a logical order for the history of social organization as exemplified in the family, and as his labors progressed he reached the solution of many related problems of anthropology—the evolution of government, of arts and industries, of the idea of property, of moral standards, etc., and the relations in genesis and growth of these with one another and with the whole of culture. When the course of evolution in the various fields had been correlated with the successive stages of culture progress—the savage, the barbarian, and the civilized—with their subdivisions, a comprehensive

scheme of human history was for the first time available to the world.

Morgan's grandest contribution to the science of mankind is thus not the elucidation of any one branch of the subject of his researches, but the opening up of a vast new field of research of which the world had no previous knowledge, and the application of the remarkable insight into human affairs thus gained to the classification and logical arrangement of the whole subject matter of anthropology.

One great thought brought out by Morgan as a result of his extended researches is that the successive stages of savage and barbaric life—characterized by turmoil, degradation, struggle, and misery untold—were but the necessary throes by means of which the race was to rise to higher levels; that the stages were as a series of crucibles in which successive purifications were accomplished, and that the unseemly struggles still manifest even among the higher nations of the present day are but a continuation of the processes of evolution tending upward to final results, the full nature and significance of which can now only be surmised.

It will not be claimed that Morgan has said the last word regarding the diversified and intricate subjects that he ventured to discuss, but he has said the first word on many problems that will not be fully solved for generations to come. He found the vast domain of American ethnology practically unexplored, and ventured boldly into pathways hitherto wholly untrodden. That the first hasty survey should have failed to reveal to him in their true relations and full significance all the diversified phenomena with which he had to deal proves only that he was human and that the field of labor is almost limitless.

Whatsoever the final conclusions with regard to the great problems with which he battled, howsoever far away he may have been at times misled by the tendency to generalize too broadly on incomplete observations, he must always remain an heroic figure on the threshold of the dawning science of primitive human institutions.

Although not possessed of great wealth, Morgan desired to contribute to the intellectual and moral progress of his kind

and bequeathed the better part of his fortune to the University of Rochester "for female education of high grade in the city of Rochester under the management of the trustees of the said University."

Morgan was instrumental in organizing the Section of Anthropology in the American Association for the Advancement of Science, at the meeting held in Detroit in 1875, and was made first chairman of that section. In 1879 he became President of the Association and presided over its meetings in Boston the following year. His home in Rochester contained a fine library and was frequented by some of the leading scholars of the time; and he was one of the founders of the literary clubs of his period and locality.

In stature he was of medium height and well proportioned. He was energetic and active, alert in manner and cheerful in disposition; an agreeable companion, easily approached, and always helpful to those in need of advice and instruction.

Having lived a singularly varied yet stainless life, Morgan died at his home in Rochester on December 17, 1881, and was buried in Mount Hope Cemetery in that city.

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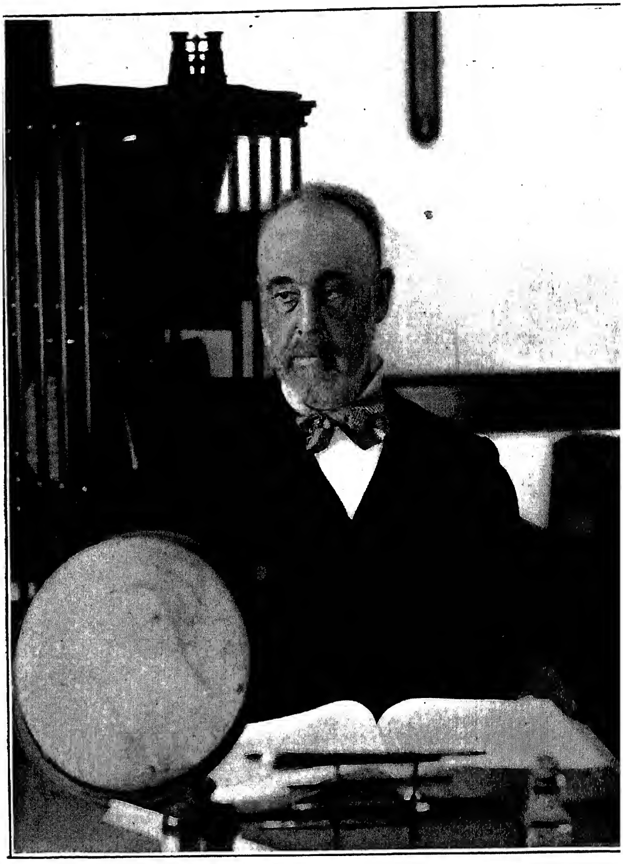

Yours, truly
Asaph Hall

BIOGRAPHICAL MEMOIR

OF

ASAPH HALL

1829-1907

BY

GEORGE WILLIAM HILL

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL 23, 1908

BIOGRAPHICAL MEMOIR OF ASAPH HALL.*

In commencing the story of a remarkable man of science, it is necessary to say something of his lineage, in spite of the generally held opinion that the details of genealogy make dry reading.†

ASAPH HALL undoubtedly descended from John Hall, called of New Haven and Wallingford to distinguish him from the other numerous John Halls of early New England (Savage makes no less than seven before 1660), and who arrived at New Haven shortly after June 4, 1639, as he is one of the after-signers of the New Haven Planters' Covenant. His movements before his arrival are in some obscurity. From his son Thomas of Wallingford receiving a grant of fifty acres of land from the General Court of the Colony at the session of October, 1698, "In consideration of his father's services in the Pequot war," it is inferred that he was a dweller in the colony in 1637. At this date there were only four settlements in Connecticut, and it is supposed that the John Hall of New Haven is identical with a John Hall who appears as the holder of lots in Hartford about 1635. The genealogists are in dispute in the matter. Mr. Shepard sums up thus: John Hall came with the advance Hooker party, in 1632, or perhaps on the *Griffin* or the *Bird* (two vessels whose arrival at Massachusetts Bay is mentioned by Winthrop), September 4, 1633. He may have been in one or both of the overland exploring parties to the vicinity of Hartford, of which John Old-

* I desire to acknowledge the great assistance rendered by Mrs. Asaph Hall and the sons of Professor Hall in the composition of this memoir. Family documents in manuscript have been, in great abundance, put at my disposition. Dr. Horigan has contributed the elaborate bibliography.

† In the matter of the lineage of Professor Hall, besides the information supplied by the family, the following authorities have been consulted: Savage's Genealogical Dictionary; Davis's History of the Town of Wallingford; David B. Hall—the Halls of New England; Hibbard's History of the Town of Goshen; James Shepard—John Hall of Wallingford, a monograph. New Britain, 1902.

ham led the first; these took place in 1633 and 1634. He came with the advance settlers to Wethersfield in the fall of 1634, or to Hartford in the fall of 1635; went to the Pequot war in 1637; then, disposing of his lots by sale as early as the law allowed him to do without forfeiture, he removed to New Haven in 1639 or 1640.

From the record that he was "freed from training" in 1665, it is inferred that he was born about 1605. He married Jane Woolen, presumably at New Haven, although there is no record of the marriage. This lady had lived in the family of William Wilkes, and had been promised a portion of £10 on the occasion of her marriage, which promise was never fulfilled. Consequently, in 1647, Mr. John Hall sued the estate of Wilkes for the amount, which the court allowed. The records of New Haven give other facts in reference to John Hall, which may be read in Mr. Shepard's monograph.

In 1670 three of his sons—John, Samuel, and Thomas—decided to take part in the settlement of Wallingford. He himself, after a residence of about thirty years in New Haven, must have followed them shortly after. In 1675 he is selectman of Wallingford. He died not long before May 3, 1676, as at this date an inventory of his estate was taken. The widow, after marrying Mr. John Cooper, died some time in 1690.

The genealogists are not agreed as to the children of John Hall, but it seems there were seven—five boys and two girls. The fourth child was Thomas, baptized March 25, 1649; he was one of the proprietors of Wallingford in 1670; there he married, June 5, 1673, Grace (Watson). This is the first marriage recorded in Wallingford. His occupation is given in the land records as "carpenter." He died as "Sergeant" Thomas Hall, September 17, 1711.

The fourth child of Thomas Hall was Jonathan, born July 25, 1679, and died January 15, 1760. He married Dinah Andrews May 12, 1703, who was born July 25, 1684, and died October 24, 1763.

The first child of Jonathan Hall was David, born October 16, 1705. He married Alice Hale, September 23, 1730. He took part in the French and Indian war, and was killed in the murderous fighting at the south end of Lake George in 1755.

Up to this time the family line we are following resided in Wallingford; but now David Hall became an original proprietor in the town of Goshen, owning two rights. This town was organized in 1739. David's son Elkanah made the settlement as required, but on his return to Wallingford his brother Asaph took his place.

The fourth child of David Hall was Asaph, born June 11, 1735. He removed to Goshen before July 4, 1758, and became a prominent citizen of that town. In the Revolutionary war he was a first lieutenant, going to Ticonderoga with his company under Col. Ethan Allen; was in the second battalion, Gen. David Wooster's regiment, in 1777; was captain in Colonel Sheldon's regiment, Second State battalion, in service against Tryon's invasion. He represented his town in general court continuously for twenty-four sessions, beginning with that of 1773; he was also a member of the convention which adopted the Federal Constitution. He remained unmarried until nearly the end of his career, when, July 25, 1799, he married Esther McNair, a woman much younger than himself. After his military services were over, he was made a justice of the peace, and a great heavy armchair is still preserved in the family, seated in which he dispensed justice to the litigious inhabitants of Goshen. Unfortunately he fell from a sled and received injuries that proved fatal. He died about March, 1800. He left about a thousand acres of land, eight or ten houses, several sawmills, etc. This was the grandfather of the subject of this memoir.

His only son, Asaph Hall Second, was posthumous, being born August 8, 1800. His mother took, as her second husband, Seth Baldwin, and died in Goshen, May 7, 1851. He was prepared to enter Yale College, and passed examinations for the sophomore class when he was about 17, but for some reason did not go. His father's estate was turned over to him at the age of 19. He attempted the occupation of a merchant, but failed through the mismanagement of his property. To retrieve his affairs he established a clock factory at Hart Hollow, in Goshen, and manufactured clocks. He used to load up wagons with them and drive south as far as Georgia, selling the clocks and finally the horses and wagon, and return home for another trip. He mar-

ried Hannah C., daughter of Robert Palmer. She was born at Goshen, August 19, 1804, and died there March 7, 1880.

These were the parents of Prof. Asaph Hall; they had six children, two boys and four girls, the Professor being the oldest. The latter was born October 15, 1829, in a house which has long since disappeared, situated on the road locally known as Goshen East street. This road for a distance of three miles passes over a plane region sloping upward towards Ivy mountain, nearly devoid of trees and wholly devoted to grass. This mountain is a Coast Survey station and has an elevation exceeding 1,600 feet, but it makes small impression of height, as the region surrounding the base is but 300 feet lower. The drainage is, on one side of the ridge, into the Naugatuck river; on the other side it passes through Bantam lake and the Shapaug into the Housatonic river. This is a bleak region at all times, but especially in winter, as there is nothing to check the course of the wind. At the time of Professor Hall's birth Goshen was a much livelier place than it is now, the population having fallen off 40 per cent in the interim. The town has been drained of its inhabitants by the attractions of factory life in the valley of the Naugatuck.

One of the earliest incidents of his life that Mr. Hall remembered was his father taking him to North pond on a summer day for a swim. He was placed upon his father's back, and then the latter struck out to cross the pond. The poor child, having never been in the water before, was in mortal terror lest he should be drowned. "Don't be frightened at the water, my son; only hang fast to papa's neck and you will be brought safely to land;" which was accomplished.*

Young Hall was, of course, sent to the "district school;" the building is still standing, although it is now used for quite different purposes than those of education. He was early initiated into the labors of farm life, beginning doubtless with driving cows to pasture.

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* This pond is strangely omitted from the map of the State by the U. S. Geological Survey. There is no excuse for this, for, though hidden by swampy woods, it is visible from at least two points on the highway running on the west side. It has an area of about 200 acres.

This bucolic state of affairs lasted until he was 13, when his father, in one of his clock-selling trips to the South, was taken ill, and died at Clinton, Georgia, September 6, 1842. This was the beginning of hardship for Asaph. His father's land was dreadfully encumbered with mortgages. Nevertheless the family attempted to redeem at least one farm. A cheese factory seems to have been started (Goshen being an excellent grazing town). Professor Hall, writing to his son Angelo, October 20, 1906, speaking of his own mother, says: "She did a great deal of hard labor. One year we sold 10,000 pounds of cheese, all made by her." This seems incredible, and a suspicion arises that an extra zero has, through inadvertence, been added. Asaph, being the oldest of the children, must have been much driven in assisting his mother, since his only brother, Lyman, was several years his junior. In spite of this great effort, the main object failed of accomplishment; it was found that the utmost that could be done was to pay the interest on the mortgages and the living expenses. At this time, to help matters, Asaph carried the mail-bag on some route in Goshen.

As there seemed to be no hope of raising the mortgages, his mother retired to a small farm which, fortunately, she owned in her own right; and he himself, or his family for him, decided that he must learn the carpenter's trade. Accordingly he was apprenticed at the age of 16 to a carpenter, the apprenticeship to last for three years. In the summer of 1847, while he was still an apprentice, he was engaged with others in drawing timber from the Canaan mountains for buildings in the Blackberry valley, and noted with surprise that the people of that valley were able to raise good melons, while he in Goshen had always failed to bring them to maturity. The 700 feet difference of elevation was the principal cause of this. Whatever he could save from his scanty wages he turned over to his mother. At the expiration of his apprenticeship he set out as a journeyman. His reputation about Goshen was that of a skillful house-builder. He himself has informed me that he built houses as far away from his home as Great Barrington, in Massachusetts.

A prominent and well-to-do citizen of Goshen, known as Deacon Norton, who was the inventor of pineapple cheeses, employed him to make the wooden moulds for shaping them; these

he made with chisel and mallet. The deacon, being a strict Sabbatarian, would say to him as he departed Saturday evening, "Now, young man, if you are reasonably quick in your motions, you can reach home before sunset."

During this period he was not without some advantages. His father having been a man of intelligence, books on a variety of subjects had accumulated about the house in much greater number than was the case with the neighbors. These he was diligent in reading at spare moments, after candles were lit or by daylight on Sundays. He was very eager to acquire information that might be serviceable in his future career. The bibliographer was innate in him. The first thing he did, on becoming interested in any subject, was to find out the names of all the prominent authors who had written on it, and the titles of their works, and this when there was small hope of his ever possessing or even seeing them. This, in after life, led him to despise the school and college text-book. "Intellectual pap, suitable only for babes," he would say. He always went to a master for instruction. When invited by the book-publisher to write a "Popular Astronomy," he made it a rule always to decline. "There is enough of such trash afloat without my adding to it."

About this time he is asserted to have entertained the ambition of exchanging carpentry for architecture. His predilection this way can hardly have been very decided, as in his after life I never heard him speak in praise of this art. As house-building was impracticable in winter, he had some leisure at this season, and managed to spend one winter at the Norfolk academy, studying algebra and six books of Euclid under the instruction of the principal.

After he attained his majority, doubtless with the approval of his mother, he began to lay up a sum of money that, in time, would suffice to pay his way through college. As his wages were only a dollar and a half a day, this was gaining way at a snail's pace. In the summer of 1854 he had accumulated about $300, and was becoming impatient to see his education begin. Having read in the *New York Tribune* a description of Central college, at McGrawville, Cortland county, New York, in which it was said that the price of tuition was remarkably low, and every student had an opportunity of paying his or her way through the

college by manual labor, he thought that this was, perhaps, just the thing he wanted. After some reflection he determined to go.

This college had been founded by Gerrit Smith, the noted abolitionist of Peterborough, and kindred spirits. They had good intentions, doubtless, but the mode of advertising their advantages produced deleterious results. Their word was "Ho! every one that thirsted, come to the educational waters and drink, without money and without price; sex and color will be taken no note of." The consequence was the gathering of a motley crowd, many of them of the adventurer type, who believe that the sole use of education is that it enables one to dispense with muscular exertion. Among them an honest man would find little sympathy.

On his arrival, Mr. Hall was somewhat taken aback by the character of the place, so different from what he expected; but he decided to remain and make the most of his opportunities. There were no masters among the teaching corps, but he doubtless found some books in the library he was glad to be able to read, and the amount of his leisure greatly exceeded that he had previously enjoyed. Here it became evident that mathematics was the science to which he was preëminently attached. However, he did not, in his short stay, get beyond the elements; perhaps the institution afforded no means to this end. He acquired some French and Latin. His knowledge of carpentry stood him in good stead, for he kept the college buildings in repair during the whole of his stay. This was only a year and a half, when Mr. Hall became convinced that he had about exhausted the advantages at McGrawville, and that it would be useless to remain to take a degree. Moreover, he had become attached to a young lady attending the institution, Miss Chloe Angeline Stickney, of Rodman, Jefferson county, New York. She graduated in the summer of 1855, and, being two years ahead of Mr. Hall in the arranged course of studies, it so fell out that he was one of her pupils in mathematics. It is asserted that he, with other members of the class, tried to disconcert her by asking questions it was supposed she would not be able to answer; but they did not succeed.

At the end of 1855 Mr. Hall severed his connection with the college at McGrawville and came home. He was now engaged

to Miss Stickney, and it was proposed that, after marriage, they should together undertake a school wherever an opening might be found. Miss Stickney had gone to Wisconsin to visit some relatives and in the hope that some school might be found in that State suitable to the wishes of herself and her affiancé. Mr. Hall joined her in February, 1856, and he also engaged in the quest for a school. These efforts were unsuccessful. Mr. Hall, who was a great hater of indecision, proposed that they should be married, and thereupon leave Wisconsin. Thus they were married at Elkhorn, Wisconsin, March 31, 1856, and started for Ann Arbor, Michigan. By this time Mr. Hall must have decided to be an astronomer.

Under date of April 2, 1856, Mrs. Hall writes to her sister Mary from Ann Arbor:

"Mr. Hall and I went to Elder Bright's and stayed over Sunday, and we were married Monday morning, and started for this place in the afternoon. Mr. Hall came here for the purpose of pursuing his studies. We have just got nicely settled. Shall remain here during the summer term, and, perhaps, three or four years."

Mr. Hall seems to have entered the sophomore class at the university, from which he passed to the junior at the next commencement. He studied French under Fasquelle and astronomy under Brünnow. For the latter he always entertained great regard as the teacher who had initiated him into the art of handling astronomical instruments. In this department of his science Mr. Hall was so apt a learner that he was at the bottom of an instrument in one-third of the time needed by the ordinary man. This struck Professor Brünnow so favorably that he was quite willing to give Mr. Hall extra attention. From this it came about that he passed out of the hands of Brünnow, after three months' instruction, well versed in the principles of observation. The practical training he could acquire by himself when opportunity offered.

Why he left Ann Arbor at this juncture is a little obscure; it could be induced only by the narrowness of his means. In order to get his degree, he would have to remain at the university two years longer, and he did not see where the money necessary for this was to come from. The couple left Ann Arbor in July, and

went to visit a relative of Mrs. Hall at Hiram, Ohio. While here an opportunity offered of school teaching at the Shalersville Institute near by. This school was conducted by them from August, 1856, to the end of the following April. The remuneration was limited to the tuition fees of their pupils, but they seem to have given satisfaction, as a purse of $60 was presented to them by the townspeople at their departure.

During all this time Mr. Hall was burning the midnight oil, and here occurred the incidents of a characteristic anecdote which he himself narrated to me. After battling several evenings with an intricate problem in the motion of the heavenly bodies without success, he jumped up, much vexed at his incapacity, saying, "If I only could consult Laplace's *Mécanique Céleste* my difficulties would vanish in a moment. I dare say they have the book in the Western Reserve College library at Hudson. Tomorrow is Saturday, when 'school doesn't keep,' and I am going to see." Accordingly, after communicating his intention to his wife, in the early morning he set off on foot for Hudson, a distance of at least 15 miles, presented himself before the librarian, who, seeing a man in linsey-woolsey, his shoes covered with dust, supposed he was a tramp and was proceeding to turn him out without ceremony. But Mr. Hall, undaunted by his repulse, by a few words convinced the custodian of books that his poverty was far less than skin deep; the book was brought out, and Mr. Hall allowed to make all the extracts he wanted; after which he returned by the same method as he had come. At this time his library was so small that it could be packed in a corner of his trunk.

Mr. Hall was firmly set in his purpose to become an astronomer, and he saw that remaining in Shalersville would not promote it; so he determined to move once more. On the arrival of the couple at Cleveland they were still undecided which way to turn, whether to go back to Ann Arbor or make trial of fortune at Cambridge, Massachusetts; but shortly a heavy gale on Lake Erie settled the matter. Mrs. Hall was frightened at the great waves and shrunk from going aboard the steamer for Detroit. She said, "Let us go East." So she proceeded to her relatives in northern New York, and Mr. Hall to Cambridge, to see what opening there might be for them there. He conversed

with the Harvard College professors, but the result was only partially encouraging. He could attend certain courses of lectures and receive help in his studies from the professors without any charge being made, but no salaried position could be guaranteed him; he would have to depend on stray scientific jobs. In this conjuncture Mr. Hall saw that it would be prudent to have a little money in his pocket before attempting settlement in Cambridge. Thus he went to Thomaston, Connecticut, and practiced again his trade of carpentry. A mill-owner in this place employed him to reconstruct the decayed apron of his dam across the Naugatuck river. At the completion of his task he was standing on the upper edge of the apron, contemplating his work with satisfaction, when, the timber being very wet from the spray of the fall, in a moment he lost his footing and slid the width of the apron splash into the pool below. The bystanders were indulging in a hearty laugh at his mishap; but the mill-owner said, "Don't mind them; you have made the best apron on the Naugatuck."

On May 19 Mr. Hall writes to his wife: "I get along very well with my work, and try to study a little in the evenings, but find it rather hard business after a day's labor. * * * I don't clearly know what we had better do, whether I had better keep on with my studies or not. It would be much pleasanter for you, I suppose, were I to give up the pursuit of my studies. I do not like to do this, for it seems to me that, with two years' more study, I could attain a position in which I could command a decent salary. Perhaps in less time I can pay my way at Cambridge either by teaching or by assisting in the observatory; but how and where we shall live during the two years is the difficulty. I shall try to make about $60 before the first of August. With this money I think I could stay at Cambridge one year, and might possibly find a situation, so that we might make our home there; but I think it is not best that we should both go to Cambridge with so little money, and run the risk of finding employment. You must come here and stay with our folks until I get something arranged at Cambridge, and then I hope we shall have a permanent home."

But Mrs. Hall insisted on sharing the lot of her husband. She indeed came to Goshen, but in six weeks the couple started to-

gether for Cambridge with the small capital of $50. On August 26 Mr. Hall entered the Lawrence Scientific School, and shortly began attendance on Prof. Benjamin Peirce's lectures. Prof. W. C. Bond had offered him $3 a week, and he had accepted the wages. Some of the devices for getting along were amusing enough. Mr. Hall found he must read the books of the German mathematicians and astronomers. Knowing the grammatical structure of the language, how was he ever to get sufficient leisure for learning the vocabulary? Mrs. Hall became a living dictionary, of which there were no leaves to be turned over, and from her Mr. Hall learned 30 or 40 new German words every morning as he kindled the fire. After some two months of this he thought himself tolerably equipped.

Early in 1858 he got some extra work—observing moon culminations in connection with Col. Joseph E. Johnston's army engineers surveying in the West. He received a dollar for each observed culmination, and in March he made 23 such observations. Mrs. Hall would awaken him out of his sound sleep in time to go to the observatory as faithfully as an alarm clock. He also eked out his small means by computing farmers' almanacs. During the latter part of 1858 he had other extra work—computing on the Colorado Survey. As to Professor Peirce's lectures, he soon ceased going to them, for he found they were too theoretical, and, moreover, there was some friction between the observatory and the mathematical department that rendered it unpleasant for him to be connected with both. Early in 1859 Mr. Hall's pay was increased to $400 a year. When Mr. Hall arrived in Cambridge, Mr. George P. Bond told him he would starve if he followed astronomy. This was not very courteous, as he himself was following astronomy at the time without starving. Mr. Hall might have retorted, "Why don't you follow your own advice?" Two of Mr. Hall's sisters visited him in Cambridge, and were so much dissatisfied with his poverty that they advised Mrs. Hall to persuade her husband to adopt some more profitable profession. Of course their advice was not followed.

Mr. Hall now began writing for the scientific journals; his earliest paper of importance is in the *Mathematical Monthly*, vol. III. It is on the transformation of an infinite series into a

continued fraction. But most of his articles gave the elements of newly discovered comets and minor planets.

A few items respecting his occupations can be extracted from Mrs. Hall's letters.

May 4, 1858: "Another new comet last night. Mr. Hall has just finished computing the elements of one. They are to be published in the *Astronomical Journal*."

December 16, 1860: "Mr. Hall is up almost every night this winter observing zones."

July 18, 1861: * * * "Big Asaph computing orbits; this will make the sixth he has done since March, I think, besides computing two almanacs and writing a long article for the *Mathematical Monthly*." (Big Asaph is a playful designation of her husband; there was now a little Asaph in the family.)

In the summer of 1862 Mr. Hall's salary was again raised; but it was still inadequate to defray the expenses of generous living, especially as the Civil War had raised the prices of all commodities. Hence, when Congress authorized four new aids for the U. S. Naval Observatory, Mr. Hall, although reluctant to leave Cambridge, determined to apply for one of these positions. He accordingly went to Washington to undergo the examination, and returned to await the result. He learned in due time that he had passed and had been appointed. On August 6 he proceeded again to Washington to remain there permanently. Mrs. Hall and her boy remained at Cambridge for a few weeks, until the disturbance caused by the fighting about Washington should somewhat subside. She rejoined her husband just after the battle of Antietam. The rude alarms of the war prevented an easy flow of existence.

August 27, Mr. Hall writes to his wife, still in the North: "I am getting along as well as I can; have not looked for a place since my visit to Georgetown on Saturday; shall go there again next week. I think we shall like Georgetown better than Washington. The Observatory is not far from there, and now that a horse railroad is built between the two towns, communication is easy. I sometimes wish I could have stayed in Cambridge. It is much pleasanter there and quieter and better for study. But we will be content. We can be happy together almost anywhere."

The second battle of Bull Run had just been fought. From the Naval Observatory Mr. Hall heard the roar of cannon and rattle of musketry. In the following letter he assured Mrs. Hall that he was safe.

Washington, September 6: * * * "You must not give yourself any uneasiness about me. I shall keep along about my business. We are now observing the planet Mars in the morning. Mr. Ferguson and I work on alternate nights. You had better take your time and visit at your leisure now. Things will be more settled in a couple of weeks."

The battles in the vicinity of Washington filled the city with wounded soldiers, some of whom were relatives or friends of the family, and not a little time was spent by Mr. Hall in looking after the latter. Some were brought to the house in which he was temporarily living, and nursed there by his wife and himself. He had a severe experience in getting acclimated to Washington, so much so that he wrote to me to exchange places with him, in a joking way, of course, as he knew the Navy Department could not allow such a thing. The military camps in and about the city produced a very unsanitary condition of things, and diphtheria and smallpox invaded the house in which he was staying, and in March, 1863, he was obliged to send his family North. He himself remained in the city through the summer. Frequent removals were necessary, and it was only after five years' stay that Mr. Hall became the owner of a permanent residence in Georgetown.

In the spring of 1863 Professor Hesse resigned; this left a vacant place in the corps of professors of mathematics in the navy. Mr. Hall's friends desired that he should be promoted to it; but he, believing that the office should seek the man, would do nothing but wait. His wife, however, thought this was too bad, and ventured to address a letter to Captain Gillis on the matter from Cambridge, Massachusetts, where she was then staying.

On May 3 Mr. Hall writes to Mrs. Hall: "Yesterday afternoon Captain Gillis told me to tell you that the best answer he could make to your letter is that hereafter you may address me as Professor Hall. * * * You wrote to Captain Gillis, did you? What did you write?" Captain Gillis was a kindred

spirit with Professor Hall, and thus the latter's promotion appears to have taken place with little friction. Thus, after many discouraging circumstances, the battle for recognition was ended.

Some pleasant incidents occurred about this time. One evening Professor Hall showed President Lincoln and Secretary Stanton some objects with the equatorial. A few nights afterwards the President, unattended, repeated his visit; he wanted to know why the moon had appeared inverted in the telescope; and when his wishes on this point had been gratified, he remained to converse generally on astronomy.

On the morning of July 12, 1864, firing was heard north of the city; General Early was threatening Washington from that side. Professor Hall went to his work as usual, but he did not return. Mrs. Hall, with her little boy, set out for the Observatory to ascertain what was become of him. A note on his table explained his absence. "I am going out to Fort Lincoln; don't know how long I shall stay; am to be under Admiral Goldsborough. We all go. Keep cool." Together with the other officials at the Observatory, Professor Hall was put in command of a number of workmen from the Navy Yard who manned an intrenchment near Fort Lincoln. Many of them were foreigners, and some of them did not know how to load a gun. However, the Observatory and Navy Yard people did not have to endure the strain of this novel position a long time, for the Sixth Corps had early been telegraphed for, and they now came up the river to relieve them.

Having now traced Professor Hall through his attempts to get a footing in the scientific arena, we are at leisure to note his contributions to the science of astronomy.

In 1863 he deduced a value for the constant of solar parallax from observations of Mars with equatorials at the observatories of Washington, Upsala, and Santiago during the opposition of 1862. As a uniform method of observing was not followed at the three observatories, the result 8.″84 has not, perhaps, a high degree of precision. Some investigations made by Professor Hall afterwards showed that the method with two micrometer wires cutting off nearly equal small segments of the planet's disk is better than with a single tangent wire.

In 1864 Professor Hall, casting about for something to do with the instrumental means at his command, determined to form a catalogue of the stars in the cluster Præsepe. Eleven of the brighter stars were determined by the meridian instruments of the Observatory, and the remainder were interpolated by means of differential measures made at the Equatorial. The number of stars determined was 151. This work stretched from 1864 to 1870. It is as good as the appliances employed permitted. Better results could, doubtless, have been obtained by the use of a heliometer.

In 1868, May 2, Professor Hall observed an occultation of Aldebaran in unusual circumstances, the moon being invisible at the time and only 8° distant from the sun (Washington Observations for 1868, p. 327).

The same year an article on the "Positions of the Fundamental Stars" was contributed to the *Astronomische Nachricten* (vol. LXXI, p. 191), in which the haphazard methods of observing in vogue at that time were criticised and some improvements suggested. Some of the latter have since been adopted.

In May, 1869, Professor Hall was ordered to observe the solar eclipse of August 7 on the eastern coast of Siberia. He proceeded to San Francisco by way of the Isthmus, and thence by the United States vessel *Mohican* to Plover bay, his destination, where he arrived July 30. The eclipse was observed, but the data obtained were of no great importance. This was due partly to clouds and partly to insufficient instrumental outfit.

Professor Hall says in his report: "With regard to the eclipse, I most sincerely regret that we had no means of taking photographs. As the weather happened to be, this was the one thing most needful for us, and I hope that our fortune in this respect may be a warning to future expeditions."

The following year Professor Hall observed the solar eclipse of December 22, at Syracuse, in Sicily. He spent the short time of totality in noting the appearance of the solar corona, and indicates his disbelief in the scientific value of hand-drawn pictures. The utmost one can do is to note the general impression produced. Deliberation in sketching an outline is impossible. In this respect it is much like the aurora borealis.

The secular perturbations of the eight major planets of the solar system was a subject that at all times interested Professor Hall. He was employed by the Smithsonian Institution to report on Mr. Stockwell's investigation. This he did in his accustomed thorough way, testing his figures in many places by his own computation. This led him in 1870 to publish an article in the *American Journal of Science* noticing the imperfections of previous treatments of this matter. He shows how important it is we should start with values of the masses quite approximate. However, it is still more important that the squares and product of the masses of the large planets, Jupiter and Saturn, should be properly taken into account in the investigation.

In 1872 he reported on observations of Encke's comet, both for position and physical appearance, during its apparition of 1871. Sixteen observations for position were obtained between November 2 and December 7.

Professor Hall says: "I first saw this comet in 1858, and have observed it at four returns. My impression is that it has been fainter during its present return than I have ever seen it before, considering its distance from the earth and sun. To an observer who sees such changes going on, the question will naturally occur whether his determinations of position made at different times and when the comet has such different forms are strictly comparable. It would appear that this should be carefully considered in any discussion of the motion of the comet."

In connection with this matter, Professor Hall, about this time, contributed to the *American Journal of Science* an article on the "Astronomical Proof of a Resisting Medium in Space." He considers that the comets of Faye and Winnecke do not support the hypothesis of a resisting medium, which Encke thought thoroughly established by the motions of his comet. Professor Hall points out the logical incompleteness of the proof of the action of a cause simply because it accounts for the observed facts; it is necessary to show, in addition, that no other cause is capable of so doing. His prevision in this matter was amply confirmed by the subsequent researches of Von Asten, when it was found that Encke's modulus of resistance had to be greatly cut down.

Professor Hall was the chief of the party sent to Vladivostok to observe the transit of Venus of December 8, 1874. Six men accompanied him in various capacities. He left Washington July 11 and arrived at San Francisco July 21. Messrs. Harrison and Gardner, in charge of the instruments of all the northern parties, made the journey from Washington to San Francisco on freight trains. The party sailed from San Francisco July 28, in the steamship *Alaska*, and reached Yokohama August 20. Leaving this place on the 26th, they reached Nagasaki August 30. On September 3, aboard the U. S. steamer *Kearsarge*, the whole party was conveyed to Vladivostok, which was reached September 7, and baggage and instruments were landed September 9.

A battle was immediately commenced with the untoward climate of Vladivostok. The party seem to have been at their wits' end how to protect their instruments and still leave it possible to observe with them. Driven away from their first chosen site by the wind, with difficulty they found a second. Professor Hall gives a somewhat sarcastic account of the conditions: "It was a puzzling question what to do with the equatorial house. The winds at Vladivostok are extremely violent, and the roof of this house was so designed as to give the winds a strong hold of it. Finally, four posts were set firmly in the ground; holes were bored in the roof of the house; strong ropes passed around the main rafters and made fast to the posts. To keep the wind out of the house, a curtain was made of old canvas, furnished by Captain Harmony, and nailed and drawn down around the body of the house. In this way the roof was made secure, and wind and snow were, in a good degree, kept out of the house. But, at the same time, the house was rendered nearly useless for ordinary observations, since if we untied the fastenings and opened the shutters we were in danger of having the roof blown off and our equatorial broken. Afterward I regretted not having followed the plan proposed by Captain Harmony and by Mr. Smith, of building a strong plank fence a few feet outside the house, bracing this fence from the inside and banking it with dirt on the outside, and letting the planks rise a few feet above the eaves of the roof; but I had such an experience in building that I very much disliked undertaking anything more in Vladivostok."

The transit instrument was found to have been very slovenly constructed. Professor Hall says: "Of the three spirit-levels furnished by the maker, two were utterly worthless, and the third was kept to be used only in case of necessity."

With regard to the photographic apparatus, he says: "The heliostat and clock had been so profusely oiled that they would not run in cold weather. They were carefully cleaned by Mr. Gardner; no oil was applied except a little at the bearing of the pendulum, and afterward they performed tolerably well. * * * In accordance with the last directions received from the commission, we had covered our heliostat pier and the coffin-shaped plate with white cloth. After this was done the photographs were blurred, and it was at first supposed that the focal distance had been erroneously measured. The coffin-shaped plate was moved and the focal distance changed to correspond with that found by experiment with ground glass, but the photographs were no better. After some delay it was found that the trouble came chiefly from light reflected from the white cloth and other surfaces to the sensitive plate. The cloth was removed and the surfaces painted a dead black color, with lamp-black and water. There still remained a source of trouble which it was impossible to avoid. This was the difference of temperatures inside and outside of the photographic house, and which varied from 20° to 50°. This allied itself with what seems to me the weakest part in the excellently designed apparatus provided by the commission for doing the photographic work—that is, with the fact that the glass mirror reflects but a small percentage of the light. The reflection of so small a quantity of light through the photographic lens made it necessary to open the slit in the slide to its greatest width, 2½ inches, and even then, at low altitudes to move the slide by hand slowly past the plate, and thus lengthen the time of exposure. But if the time of exposure was much lengthened, the difference of temperatures made the photographs blurred and indistinct around the edge of the sun. It was decided to make faint and sharp photographs rather than those with blurred edges, and as dense as the photographers had been instructed to make."

"On the morning of the day of transit the apparatus was in good adjustment, and Mr. Clark and his assistants had every-

thing in readiness for making 200 photographs. At the time of the first and second contacts the haze prevented them from making any photographs, although the telescopes gave us faint but very fine images of the sun and Venus. After Venus had entered wholly on the sun's disk the haze became thinner, and a few photographs were made, when we were stopped by denser haze. About an hour after this another set of photographs was made, and still later, and near the end of the transit, nine photographs were made. There are 13, I think, that will admit of measurement. The others will be found probably too faint to be used."

Thus, on account of atmospheric haze and imperfect apparatus, the expectations entertained were not fulfilled.*

In 1866 and 1867 Professor Hall was assistant to Professor Newcomb on the new transit circle. For a few months at the end of 1867 he was in charge of this instrument. From 1868 to his departure for Vladivostok he was in charge of the small equatorial. In May, 1875, he was put in charge of the Clark refractor, which he held to his retirement.

In 1875 he proposed to derive the mass of Mars from the motions of the minor planets, whose periods are nearly double that of the first-mentioned planet. He gives the formulas for deriving the coefficients of the long-period terms in the longitude of the minor planet, and a table to facilitate the computation, and then makes application to 32 of these bodies. The practical objection to this is that we have to wait until a large fraction of the period has elapsed.

On December 7, 1876, Professor Hall noticed a brilliant white spot on the ball of Saturn. It continued to be visible until January 2, 1877. He immediately made use of it to determine the time of rotation of Saturn. Sir William Herschel had made a determination, but the statement of it in the books had got vitiated.

In a memoir of the same year (1877) he considers the equation of the curve of the outline of the shadow of the ball of

* I have not been able to find Professor Hall's report printed in any scientific journal or collection. Fortunately, what appears to be an unabridged edition of it is published in the *New York Daily Tribune* for March 26, 1875.

Saturn on the ring. The treatment of this question is greatly simplified by the consideration that the diameter of the sun as seen from Saturn is only about 3′; hence, for all practical purposes, it suffices to reduce that body to a point. But Professor Hall treats the question in its most general form, and the equations evolved are interesting from the mathematical side.

We now come to the principal achievement of Professor Hall, the discovery of the two satellites of Mars. The exploit created so much excitement in the scientific world at the time that even now, after the lapse of thirty years, the history of it seems very trite. Of course, when men have made a long and painful search for a thing without success, they feel warranted in saying it does not exist. In this way the text-books repeated the statement, "Mars has no moon." But the opposition of Mars in 1877 was a very favorable one, and, still more, the instrument Professor Hall had at command considerably exceeded in space-penetrating power any that had been previously constructed. On these accounts he thought that it could not be laid to his charge that he had wasted his energies, even if he discovered nothing, for negative knowledge is sometimes as valuable as positive.

Mars reached its stationary point August 5, and a month later it was in opposition. The search was begun early in August. Between the 4th and the 10th no observations are recorded, but on the 10th Mars' white spot is observed, with the remarks: "Planet blazing; clouds passing." On the 11th the remark is: "Seeing good for Mars." At 14^h 42^m a faint star near Mars was measured (this was Deimos), when fog from the Potomac interrupted observation. Unfavorable weather continued to August 15, when the white spot of Mars is seen, and the remark is: "Images blazing." On the 16th Deimos is seen and measured twice, the result showing that it was attending Mars. On the 17th not only is Deimos seen, but a new object is detected. To the later observation is added the remark: "Daylight. Both the above objects faint, but distinctly seen by George Anderson and myself." The observations of the 17th and 18th clearly established the character of these objects, and Admiral Rodgers publicly announced the discovery. For some time the inner moon was a puzzle, but by making a prolonged watch on the nights of August 20 and 21 the identity of the object at its several appear-

ances was made out. The glare of Mars so generally interfered with the visibility of the satellites that it was necessary to slide the eye-piece so as to keep the planet outside the field of view.

This discovery produced a great sensation. I remember visiting my bookseller in New York just as the public announcement was made. The first thing he did on my entering his place was to thrust the morning paper under my eye and point to an editorial, with "What do you think of that?" I took time to read the heading and the first line, and replied, "That's a moon hoax." Information came from Washington the next day that effectually disposed of this view. A craze for discovering satellites took possession of many people. One man in Pennsylvania, the owner of a small telescope, wrote to Professor Hall, "I have discovered a satellite, and it goes round the primary in five seconds." Envy, too, was not wanting; but Professor Hall could afford to stand by and smile; the joke was all on his side.

As to the amount of credit due to Professor Hall in this matter, it is certainly a singular fact that after the discovery no astronomer put in a claim that he also had intended to prosecute a search for satellites, but had not yet taken opportunity to commence work. Thus it would seem that Professor Hall in 1877 was the only astronomer who indulged such an intention and carried it out. We shall do no one a wrong in saying that if it had not been for Professor Hall the great opportunity of 1877 would have passed without the discovery of these bodies. Professor Hall was an exceedingly modest man in reference to his achievement—modest beyond what the occasion called for. He more than once said to me, "Mr. George P. Bond should have discovered these satellites in 1862; his telescope was powerful enough to reveal them." I would reply in a bantering way, "He very kindly left the nuggets for you to pick up." After the discovery, it was surprising what a number of relatively small telescopes revealed these satellites; so much easier is it to discover what has already been discovered.

Measurement of these satellites continued to be the care of Professor Hall until he closed his work at the U. S. Naval Observatory, in 1892.

Professor Hall reported on the transit of Mercury of May 6, 1878, which he attended to in Washington. Mr. Joseph A.

Rogers having made 216 dry plates, 72 of them were exposed in Washington. The third and fourth contacts were observed; the others were missed. The diameter of the planet was measured with the double-image micrometer, but the results were deemed of slight importance.

The same year he journeyed to Colorado to observe the solar eclipse of July 29. His station was La Junta, on the line of the Atchison, Topeka and Santa Fé railroad.

Professor Hall reports: "The day at La Junta was all that could be desired for observing a total eclipse. My own special work during totality was searching for an intra-mercurial planet, the supposed Vulcan, indicated by the researches of Leverrier on the orbit of Mercury. Before the eclipse I studied the configuration of the stars as they are laid down on the chart published by the Observatory, and during totality a copy of this chart was placed a few feet in front of me, so that I could refer to it instantly. As soon as totality began I turned my shade to the free opening and commenced sweeping above the sun and near the ecliptic. My sweeps extended from the brighter part of the corona to a distance of about ten degrees from the sun. The magnifying power was so great that the sweeping could not be done very rapidly. In this part of the sky I saw nothing but the stars laid down on the chart. * * * The interior part of the corona seemed to me very bright—much brighter than the corona I saw at Syracuse, Sicily, in 1870. * * * The darkness during totality at La Junta was very slight, and I could read my chronometer and could see the stars on the chart with ease and without the aid of artificial light.

"At La Junta I was struck with the clearness and beauty of the sky at night. I could see distinctly and steadily with the naked eye λ Ursæ Minoris, a star that I have never been able to see at Washington in this manner, although I have made many trials and know, of course, just where to look. The number of stars visible to the naked eye was greatly increased. But the most striking change was in the appearance of the Milky Way. The outlines and divisions of this great starry ring were seen with wonderful distinctness. A few hours after sunset, when the intense heat of the ground had passed away, the images of stars in our telescopes were good. I cannot but think that those elevated

plains offer advantages for astronomical observations that have not hitherto been made use of. An obvious objection to the use of large telescopes in those regions is the great change of temperature from day to night. It might be necessary that the observer should work from midnight until morning, but these are generally the best hours of the night at any place. This interesting question will not, I think, be definitely settled until a complete and careful experiment has been made. The reports of observers who have had an experience of a few days or weeks are apt to be conflicting and unsatisfactory. The elevated plains of our country are now easy of access, and in order to decide the question, an experienced astronomer with a good telescope should be placed in an elevated position, and should continue his observations for several years."

As more than one astronomer, on this occasion, announced the discovery of intramercurial planets, Professor Hall's remarks have an interest.

In 1880 Professor Hall gathered together and published his observations, 1,614 in number, of double stars. They include a few made in 1863 with the smaller equatorial. In the introduction, which is an admirable exposition of the difficulties which beset the observer with an equatorial, Professor Hall is very frank in stating the imperfections of the driving clock and the dome as well as the imperfection of his eyes.

In 1882 was published an investigation of the parallaxes of α Lyræ and 61 Cygni from observations with the large equatorial. A sensible temperature coefficient was found for the revolution of the micrometer screw, although previously it had been assumed that it was insensible. An abbreviated statement of the observations of α Lyræ made at the prime vertical from 1862 to 1867 is appended, showing a negative parallax.

In the autumn of 1879 the satellites of Mars were again observed. Professor Hall says: "The observations were made in the following manner: In order to avoid sliding the eye-piece, as was done in 1877, a piece of colored glass, covering one-half the field of view, was inserted in the forward end of the eye-piece, near the micrometer wires. It might be better to silver one-half the forward lens of the eye-piece, but an attempt to do this did not give a good result. In making the observations, the planet

was placed behind the colored glass, through which the wire could be seen, and, both objects being kept near the center of the field, the angle of position and the distance were measured by bisecting the disk of the planet and the satellite. In this way the observations were made in much less time than by sliding the eye-piece." Both satellites were remarkably near the predicted position, and the corrections of the elements of their orbits deduced from this series of observations were quite minute.

Professor Hall was chief of the party that was sent to San Antonio, Texas, to observe the transit of Venus of December 6, 1882. He was measurably successful and brought away a considerable number of photographs. I have not been able to find his report in print.

In 1884 he discussed the observations of Hyperion. From 1852, when Lassell had observed this satellite of Saturn, up to 1875, when Professor Hall commenced to observe it, no observations had been made. The discussion brought out the interesting facts of a nearly constant eccentricity and a peri-saturnium retrograding about 20° a year. Professor Hall gave expressions for the perturbations arising from the action of Titan. These data soon led astronomers to perceive that Hyperion afforded an example of a periodic solution in the problem of three bodies. There was still some debate as to the mass of Titan; but this was soon settled.

His being in charge of the Clark refractor seemed to point him out as the man who should have the care of all the satellites of the solar system, excepting those of the earth and Jupiter. Hence in 1885 he published a discussion of his observations of Oberon and Titania, reaching from 1875 to 1884, deducing corrections to the elements and the mass of Uranus.

The satellite of Neptune was treated in a similar manner in another memoir composed about the same time.

Next Iapetus was investigated, the longer time this satellite has been known and the slowness of its motion demanding more extensive treatment. The memoir containing this investigation is among the most admirable pieces of astronomical literature. Nothing can exceed the clearness and precision of its statements, both on the observational and mathematical sides. We are reminded of Bessel. After the lapse of a quarter of a century, it is

scarcely superseded. The amount of pains taken to have everything right is a subject for wonder. The elements are deduced from ten years' observations, extending from 1874 to 1884, except that observations of Sir William and Sir John Herschel were used in getting the period. The mass of Titan is assumed at a 10,000th part of that of Saturn; it is now known that it is more than double this. The mass of Saturn, derived by Professor Hall from his measures of the distance between the two bodies, is half a per cent greater than is indicated by the action of the planet on Jupiter. It will be noticed that the observations of 1874, 1883, and 1884 give a result that is quite different from that of the years 1875-1881. Some abnormal appearance of Saturn and its ring must have interfered with the measurement of the distance between the two bodies. Tables for the motion of the satellite conclude the memoir.

When the memoir on Iapetus was finished Professor Hall immediately took up the six inner satellites of Saturn and treated them on a plan precisely similar to that followed in the preceding memoir. Here he found a mass of Saturn still larger than that just mentioned; and a similar cause must have acted to vitiate the measurements of distance.

This was followed by the memoir entitled "Observations for Stellar Parallax," in which Professor Hall, after detailing his efforts to obtain a more certain value of a revolution of the micrometer screw, gives and discusses his observations for the parallax of two stars and rectified his previous discussion of the parallaxes of α Lyræ and 61 Cygni, it having been discovered that the correction for temperative had been applied with the wrong sign. For the latter stars some new observations were added to the discussion.

In 1889 Professor Hall gathered together the various notes he had made on the appearance of Saturn and its ring in the interval 1875–1889. The memoir contains also the measures he had made of the dimensions of the ring and their reduction. But the principal statement is the showing that the theory of Otto Struve, asserting the imminent precipitation of the ring upon the ball, was without warrant.

During these years Professor Hall was much engaged with the matter of removing the U. S. Naval Observatory to a new site.

This question was agitated for a long time before Congress authorized the removal and appropriated money for purchasing a new site. The unhealthfulness of the locality occupied by the Observatory was conceded by all who were in a position to know. This, however, was not sufficient to overcome the inertia; but at length it was seen that the Observatory would probably be in the way of the schemes for improving the water front of Washington. Thus Congress was induced to provide the sum necessary. A large number of places were offered to the Government for the purpose, and a board composed of Observatory officials was appointed to ascertain the advantages of each place and to report thereon. Professor Hall was a prominent man on this board. A very thorough investigation was made, and the present site of the Observatory (then known as the Barber place) was recommended. This so offended the unsuccessful offerers that they accused the board of undue partiality. The Navy Department thought best to appoint a new board, composed of scientists at a distance from Washington; but the new board simply confirmed the recommendation of the first. After the site was purchased, there was a great deal of friction in getting the new buildings erected. The first contract, after the time had been lengthened, was declared forfeited and a new one was formed. It was not till 1892 that the instruments were moved into the new quarters.

From the autumn of 1885 to the spring of 1887 Professor Hall measured the positions of 63 small stars, relative to the brighter ones in their neighborhood, of the group of the Pleiades. This was done in order that in the future it might be determined whether the two classes of stars had a general relative proper motion. The average magnitude of the small stars was 12.4.

About the same time Professor Hall was observing to get the stellar parallax of α Tauri. His result was only one-fifth of that of Otto Struve.

The next memoir of Professor Hall is on the constant of aberration. In this he gathers and discusses the equations resulting from the observations of α Lyræ made at Washington with the prime vertical instrument in the years 1862-1867. Some suspicion attached to these observations because they give a negative parallax for the star; but Professor Hall thought that the value of the constant of aberration derived from them was not

greatly vitiated by this circumstance, and he declares his impression that the method of getting the constant of solar parallax from that of aberration is the best astronomers now have.

In a memoir on the extension of the law of gravitation to stellar systems, Professor Hall expresses the opinion that we are hardly warranted at present in making the extension.

As Professor Hall was to be retired on October 15, 1891, having then attained the age of 62, just before retirement he collected his observations of double stars made during the interval 1880-1891.

In the year 1889 the orbit plane of Iapetus returned to a position similar to that of 1875, except that the apparent motion of the satellite was reversed; hence in this year Professor Hall began another series of observations which were continued in the opposition of 1890. The principal result of the discussion of these was a smaller value of the mass of Saturn than was obtained in the earlier investigation, but still larger than the commonly accepted value.

In a memoir of 1892 on the relative motion of 61 Cygni, Professor Hall discusses his own and his predecessors' observations, with the result that the two components are physically connected. The addition of terms proportional to the square of the time brings the theory in accord with observation.

In a supplement to his second collection of observations of double stars, Professor Hall derives formulas representing the coordinates of the more interesting.

Although Professor Hall had been retired, the Superintendent of the Observatory tendered him the use of the Clark refractor for observing the satellites of Mars in the summer of 1892. The discussion of the observations is found in the *Astronomical Journal,* vol. XII.

Having, in the just-mentioned memoir, deduced a new value for the revolution of the micrometer screw,. Professor Hall, in another article on the masses of Mars, Saturn, Uranus, and Neptune, modified his previously given values of these masses to accord therewith.

In a memoir of 1893 the perturbations of Flora by Mars and the earth are somewhat rudely derived, but with sufficient detail to show that they are of no great moment.

In "A Suggestion in the Theory of Mercury," a memoir of 1894, Professor Hall, using a formula of Bertrand, showed that the unaccounted-for part of the motion of the perihelion of Mercury could be explained if the exponent —2 of gravitation was algebraically diminished by a very small fraction. This suggestion was adopted by Professor Newcomb in forming his tables of the interior planets.

The same year Professor Hall published a memoir on the orbits of double stars, giving a very lucid exposition of the formulas and methods for deriving them from the observations.

In 1896 Professor Hall published the absolute perturbations of Nemausa of the first order by Jupiter. They are compared with normals covering 34 years of observation, and the accord is so good that tables might be constructed from this investigation accurate enough to give fair positions of this planet in the future.

In 1898 Professor Hall discussed the observations of the satellite of Neptune made during the preceding opposition, at the Yerkes Observatory, by Professor Barnard, and derived a new set of elements. He points out the desirability of continuing observations of this sort in order that the ellipticity of the planet may be determined.

Two years later Professor Hall, then residing at Cambridge, used his opportunity to investigate, as far as the preserved documents permitted, the observations of this satellite made by the two Bonds in 1847 and 1848. The conclusion he comes to is that the methods of treatment adopted for the Cambridge observations is quite superior to that followed at Pulkova.

In 1902 Professor Hall has a memoir considering the mass of the rings of Saturn. He first assumes plausible values for the elements of the problem, which lead to a negative value for the mass under consideration. However, it is easy to make such changes in the elements as will render the mass positive. The nebular hypothesis would lead us to suppose that the mass of the rings relatively to the mass of Saturn is not greater than the mass of the interior planets of the solar system relatively to that of the sun.

The last article Professor Hall contributed to the scientific journals is on stellar parallax, and bears date September 20, 1906.

From the preceding exposition it will be seen how varied and numerous were Professor Hall's investigations in astronomy in the course of little less than half a century.

A few details must be added concerning Professor Hall's social life after he was retired from active service in the United States Navy. In July, 1892, Professor Hall had to endure the sorrow of losing his wife. This lady, of great refinement and culture, but frail physique, had by her encouragement, sympathy, and self-sacrifice been of great service to her husband in the pursuit of his science. Having finished his work at the Observatory at the end of the summer of 1892, Professor Hall still lingered at his residence in Georgetown, frequently resorting to the Observatory library for scientific reading; but in the summer of 1894 he began to think that the ties binding him to Washington were of the slightest, and to indulge a wish to pass the rest of his days in the midst of rusticity. This led him to think of his native town, Goshen, where most of his relatives resided. Proceeding thither, he purchased a small piece of land with a house. The latter had been built shortly before the Revolutionary War and had served as a tavern, at which a line of stages, running to and from Albany, stopped in the period following this war. In order to be fit to live in, this dwelling had to be renovated, and Professor Hall spent the autumn and the following spring in attending to this work. In taking up the flooring some coins of colonial Connecticut were discovered. This dwelling stands on the road between Litchfield and Norfolk, about 200 yards south of the crossing of it by the Gunstock brook, the outlet of North pond. This is a very retired spot, the nearest railroad station, at Norfolk, being seven miles distant. The screech of the locomotive is not heard or only at rare times, and then very faintly. Telegraph or telephone poles are not visible on the road. This place is about two miles north of where Professor Hall was born. He dubbed it "Gunstock."

In 1896 he received an invitation from Harvard University to give instruction in celestial mechanics. Acceptance of this would involve an interruption in his plan of rustic life; nevertheless he decided to accept; but he stayed in Cambridge only during term time, all his vacations being spent at "Gunstock." At first his position at Harvard did not make him a member of

the faculty; but it was soon discovered that he was a capital man in the social line, and his rank was so changed that he became a member of the governing board. His lectures were addressed to undergraduates and made an elective course for the obtaining the bachelor's degree. Professor Hall therefore could not indulge in research work before his class. As Gauss' *Theoria Motûs* mainly turns on spherical trigonometry, in which the students coming to him should be proficient, he adopted this book as outlining the drift of his teaching. After five years of this occupation, being now 72, he thought himself warranted in retiring to his rustic home.

In the autumn of 1901 he married Miss Mary B. Gauthier, who survives him.

Planing off the summit of a large rock near his door, he bolted to it an iron sun dial constructed after his own plan. He had some difficulty in getting the foundrymen in Torrington to follow precisely his drawing. The light of the sun was compelled to go through a conical perforation in the style ending in a pinhole. This formed a minute star on the horizontal plane of the dial which had a deep groove on the line of the meridian. The bisection of the star by the sharp line at the bottom of the groove marked the time the sun's center was on the meridian. By this device Professor Hall thought he got time correct to within 20 seconds. The dial was kept painted, and when not in use was covered by a wooden box. When the neighbors found out that Professor Hall had good time, they came to the house to set their watches.

To get the geographical position of his house, Professor Hall made a rude triangulation connecting it with the summit of Ivy mountain.

Almost the last episode of Professor Hall's career was a deputation of his fellow-townsmen waiting on him to see if he would not represent them in the Constitutional Convention, since he was by far the most notable man in the town; but his reply to them was, "Gentlemen, I think you do an injustice to your fellow-citizens who have the misfortune to live in the populous towns. If I go to the convention, I must vote for the reform of this abuse." The deputation, with downcast countenances, went

off to find a candidate elsewhere, wondering how a man could be so quixotically altruistic.

About January, 1907, Professor Hall found himself incapable of performing the domestic labors about his house. One day he said to his wife, "I can't swing the axe; what do you suppose is the matter with me?" His friends were alarmed about his condition, and a medical examination showed heart trouble. Forbidden to exert himself, he was still able to walk about the house and grounds and ride to the neighboring villages. He spent the early spring at Annapolis, Maryland, where his son Angelo holds a position in the U. S. Naval Academy. Returning, he spent the summer at home; but at the beginning of November it was deemed prudent to remove him from the rigors of the Goshen winter. He seems to have endured the fatigues of the journey to Annapolis tolerably well, but he had not been there quite three weeks when the end came. He died November 22, 1907.

In noting the character of Professor Hall as a scientist and as a man, we observe that he has been called a self-made man, and this partly in commendation, partly in commiseration. But this statement is misleading, if it is supposed that it is equivalent to the fact that he had no continuous academic training. Whatever his surroundings, he always grasped any tool within his reach that would serve his purpose, and wielded it vigorously. If he had been wealthy enough to have employed a coach, I am afraid the coach would soon have been left behind, such enormous strides he was accustomed to take. Mr. Hall was a bird of the species that can run as soon as it is out of the shell. His battle was rather with poverty than lack of instructors. Speaking to me of his great admiration for the histories of Gibbon and Hume, he said: "What a fortunate circumstance it was for me that these books were in my father's library." He had actually read them as soon as he could read at all, and with a comprehension and appreciation equal to that of a man of forty. Perhaps he was the only boy of his age in Connecticut who indulged in that sort of reading. Dickens' Child's History of England was thrown away in his case. In a letter to me of February 16, 1873, he says: "Some fifteen years ago it was my ambition to own a copy of Bowditch's Translation of the *Mécanique Céleste*. Now I am thankful I did not have money enough

to buy it. How much more elegant the original is!" Mr. Hall had a hearty contempt for the process that makes a man a senior wrangler by damming the stream of intellectual effort so as to have the beauty of a waterfall. He was the determined foe of pedantry in learning, the persistent nibbling at the shell for the sake of showing off; he struck for the kernel at the earliest possible moment. He said, "The best book from which to learn the principles of the infinitesimal calculus is Euler's *Introductio ad Analysin Infinitorum;* there is no nonsense in it." This view does not suit the modern pedagogue in mathematics, but it is characteristic of the man who uttered it. Mr. Hall indulged in the luxury of having favorite authors, and it was sometimes difficult to persuade him that somebody outside the list was worth looking at. His favorites in the line of mathematical astronomy were Lagrange, Laplace, Gauss, Hansen, and Bessel.

He had an Aristophanic vein in his composition, but only indulged it before intimate friends, and was never malicious. In the Platonic dialogue Phædrus says: "I am going for a walk outside the walls." It seemed to me that Mr. Hall was always walking outside the walls, so much did he emancipate himself from custom and tradition.

He was eminently a democratic man, and disliked the naval etiquette of putting on airs of superiority and keeping one's inferiors in rank at a distance. During his long career of work with the Clark refractor, Mr. Hall was assisted by Mr. George Anderson, who, on the score of having served in the civil war, had obtained the position of a laborer at the Observatory. Mr. Anderson was exceedingly efficient in managing the dome and the driving clock. Professor Hall threw aside all ceremony in his intercourse with Mr. Anderson. Two brothers could not have been more intimate. Professor Hall would call Mr. Anderson to the eye-piece of the telescope. "Well, George, what do you see?" George would describe. "Well, how is it situated?" George would again describe in his homely way. "Well, I think we may enter on the observing book that we both saw it."

Mr. Hall had a wholesome dread of "subjectivities." He knew that Sir William Herschel had announced four satellites of Uranus that turned out to be "subjectivities," and at Pulkova

they had long observed a "subjectivity" as a companion of Procyon. He determined, if possible, to escape such mistakes.

For mental relaxation Mr. Hall went to literature. He was fond of history, frequently read novels, and also poetry to a small extent. In science he did not venture outside of mathematics, astronomy, and physics.

Mr. Hall was generous to a fault. But what a world of gratitude we owe him for his heroic, herculean perseverance! I do not suppose that he ever suffered from hunger, but he had only to look out of the window to see the wolf at the door.

Professor Hall's achievements were such that honors could not fail to be heaped upon him. Elected into the National Academy of Sciences in 1875, he served as its Home Secretary for twelve years and its Vice-President for six. He was an honorary member of nearly all the scientific societies in this country and Europe which make it a point to have honorary members. For some years he was Consulting Astronomer to the Washburn Observatory at Madison, Wisconsin. He several times delivered addresses in his capacity of president of a society, the last time being before the American Association in 1902 at Pittsburg. He received the gold medal of the Royal Astronomical Society, the Lalande and Arago Prizes from the Academy of Sciences at Paris, the degree of LL. D. from Harvard and Yale.

The portrait at the head of this memoir represents him as he appeared in his prime. It is from a photograph taken by Mr. Peters, the photographer to the Observatory, as he was sitting at a desk in the new Observatory.

PUBLISHED WRITINGS OF ASAPH HALL,

Professor of Mathematics, U. S. Navy.

COMPILED BY WILLIAM D. HORIGAN, LIBRARIAN.

(Communicated by Captain W. J. Barnette, Superintendent of U. S. Naval Observatory.)

The following list contains all the titles that could be collected in time for the April meeting of the Academy. There are many journals, especially among those devoted solely to mathematics, in which the minor articles are not indexed. In the class of general science, some of the journals have no author-index and some have published no index whatever. To have examined these journals thoroughly would have consumed a much longer time than that allowed for the compilation of the list; therefore it may be properly inferred that the list is incomplete, though it is believed to contain every paper of importance.

It should be noted that while assistant at the Harvard College Observatory, during the years 1857 to 1862, Mr. Hall was employed on the transit circle with the passages of clock stars and with lunar culminations in connection with the Lake surveys carried on by the Engineer Corps of the Army. He observed Donati's Comet in 1858. He "thoroughly revised" the Second Series of the Harvard Zones, and with Mr. T. H. Safford prepared the Third Series for the press. The results of these labors are contained in the Annals of Harvard College Observatory, vol. 2, part 2, and in vols. 3, 4, and 6.

Excepting the appendices to the Washington Observations, comparatively few separates of Professor Hall's papers have been found. It was his custom to distribute the copies allotted to him among individuals interested in their contents, rather than to libraries likely to contain sets of the journals. Only a few of the more important reviews have been noted.

The name of the U. S. Naval Observatory has been elided from many of the titles; so it must be understood that all observations have been made at that institution unless it is otherwise stated. In entering the many papers containing equatorial observations, an attempt has been made to add to each title a list of the objects observed by Professor Hall.

Except in the mathematical formulæ or where the number of an asteroid is indicated, parentheses denote the parts of titles transposed, while brackets inclose matter inserted by the compiler. The abbreviations used for the periodicals are those of the Catalogue of Scientific Papers, compiled and published by the Royal Society of London. In the case of a few journals which have been started since the last volume of the above was published, the abbreviations have been taken from the International Catalogue of Scientific Literature.

1858.

1. Elements and ephemeris of the first comet of 1858. Astron. Journ., 5, 1856–58, p. 120.

2. Elliptic elements of Comet 1858, I. Astron. Journ., 5, 1856–58, p. 138.

3. [Elements of Comet III, 1858.] Astr. Nachr., 48, 1858, col. 331.

4. [Errata in Gauss's *Theoria motus*.] Math. Month., 1, 1858–59, pp. 115, 190.

1859.

5. [Elements of Comet 1859, I.] Astron. Journ., 6, 1859–61, p. 24.

6. Rising, setting, southing places, and eclipses of the sun and moon; the phases and age of the moon; the rising, setting, and southing of the most conspicuous planets and fixed stars; equation of time; the sun's declination; planets' places in right ascension and declination; the time of high water at Philadelphia, etc. Friends' Almanac for the years 1859–64; published by T. Ellwood Chapman, Philadelphia.

7. A number n of equal circles touch each other externally and include an area of a square feet; to find the radii of the circles. (Prize solution of Problem III.) Math. Month., 2, 1859–60, pp. 76–77.

1860.

8. [Observations of occulations of the Pleiades, made at Cambridge, 1860, March 26.] Brünnow, Astr. Notices, No. 19, 1860, p. 147.

9. Orbit of Comet III, 1860. Brünnow, Astr. Notices, No. 24, 1861, p. 189.

10. Show that in the parabola the half sum of the radii vectores, drawn to the extremities of any arc whatever, is equal to the radius vector drawn to the summit of the diameter passing through the center of the chord and parallel to the axis, plus the part of this diameter intercepted between the arc and the chord. (Prize Problem V.) Math. Month., 3, 1860–61, p. 33.

1861.

11. Elements of Comet II, 1861 [with ephemeris]. Amer. Journ. Sci., 32, 1861, pp. 259, 260.

12. Elements of Titania [to which is added a list of typographical errors in Davis's translation of the *Theoria motus*]. Astron. Journ., 6, 1859–61, p. 191.

13. Elements of Minor Planet (66). Astron. Soc. Month. Not., 21, 1860–61, p. 240; Astr. Nachr., 55, 1861, col. 299; 57, 1862, col. 130; Brunnow, Astr. Notices, No. 25, 1861, p. 4.

14. Orbit of Comet I, 1861. Brünnow, Astr. Notices, No. 26, 1861, p. 12.

15. To change a series into a continued fraction. Math. Month., 3, 1860–61, pp. 262–268.

1862.

16. Observations upon Planet (73). [Made at Cambridge by G. P. Bond, T. H. Safford, and A. Hall.] Astr. Nachr., 57, 1862, col. 310.

17. Observations of comets and small planets made at the Observatory of Harvard College. [By G. P. Bond, T. H. Safford, and A. Hall. Mr. Hall observed comets I and II, 1861, asteroids (30), (66).] Astr. Nachr., 57, 1862, col. 353–368.

18. [Elements of the planet Clytia (73). Elements of Comet III, 1861.] Astr. Nachr., 58, 1862, col. 29-30.

19. Elements and ephemeris of Maja (66). Astr. Nachr., 58, 1862, col. 87.

20. Elements of Comet I, 1862. Astr. Nachr., 58, 1862, col. 89.

21. Ephemeris of Comet I, 1862. Astr. Nachr., 58, 1862, col. 90.

22. [Elements and ephemeris of Comet II, 1862.] Astr. Nachr., 58, 1862, col. 203-204.

23. Observations of asteroids and of the Comet II, 1862 . . . By J. Ferguson and A. Hall. [Mr. Hall observed Comet II, 1862, asteroids (32), (74).] Astr. Nachr., 59, 1862-63, col. 115-122.

24. Table of zenith distances to 80°, for the latitude of the U. S. Naval Observatory. [By James Ferguson and Asaph Hall.] Washington Obs'ns, 1861, pp. 349-358.

25. Tables of differential refraction, for the latitude of the U. S. Naval Observatory, from $+30°$ to $-30°$ of declination, and to 80° of zenith distance, $d'-d$ being constant and equal to 600″. [By James Ferguson and Asaph Hall.] Washington Obs'ns, 1861, pp. 359-374.

26. Tables of parallax for the latitude of the U. S. Naval Observatory, and a horizontal parallax of 10 seconds. [By James Ferguson and Asaph Hall.] Washington Obs'ns, 1861, pp. 434-438.

1863.

27. Observations of comets and small planets, made at the Observatory of Harvard College, Cambridge. [By G. P. Bond, T. H Safford, and A. Hall. Mr. Hall observed Comet III, 1862, Asteroid (73).] Astr. Nachr., 60, 1863, col. 33-42.

28. Observations of Comet II, 1863 . . . By James Ferguson and Asaph Hall. Astr. Nachr., 60, 1863, col. 123-126.

29. Ephemeris of Maia (66). Astr. Nachr., 60, 1863, col. 175-176

30. Observations of asteroids . . . By James Ferguson and A. Hall. [Mr. Hall observed asteroids (48), (51), (64), (79).] Astr. Nachr., 61, 1863-64, col. 209-212.

31. Observations with the equatorial, 1862. Right ascensions and declinations of asteroids and comets, observed with the equatorial, 1862. [By James Ferguson and Asaph Hall. Commencing August 7, 1862, Mr. Hall observed Mars, Comet 1862, II, asteroids (32), (74), miscellaneous double stars.] Washington Obs'ns, 1862, pp. 405–509, 510, 581–585.

1864.

32. Observations of minor planets [and of comets] . . . By James Ferguson and Asaph Hall. [Professor Hall observed comets IV and VI, 1863, asteroids (17), (25), (34), (52), 79).] Astr. Nachr., 62, 1864, col. 311–318.

33. Observations of asteroids and of Comet II, 1864. By James Ferguson and Asaph Hall. [Professor Hall observed Comet II, 1864, asteroids (2), (3), (9), (12), (16), (36), (42).] Astr. Nachr., 63, 1864–65, col. 205–208.

1865.

34. Elements of Comet IV, 1864. Astr. Nachr., 64, 1865, col. 121–124.

35. Observations of asteroids and comets . . . [By James Ferguson and Asaph Hall. Professor Hall observed Comet IV, 1864, asteroids (1), (19 , (27), (29), (37), (38), (40), (48), (60), (64), (81).] Astr. Nachr., 64, 1865, col. 177–182.

36. Observations of asteroids and comets . . . [By James Ferguson and Asaph Hall. Professor Hall observed Faye's Comet, asteroids (5), (6), (8), (13), (14), (24), (30), (31), (32), (34), (46), (49), (56), (61), (63), (67), (72), (78), (79).] Astr. Nachr., 66, 1865–66, col. 33–42.

37. Elements and ephemeris of Terpsichore (81). Astr. Nachr., 66, 1865–66, col. 55–58.

38. On the orbit of Comet III, 1858. Astr. Nachr., 66, 1865–66, col. 137–140.

39. "From the middle point of each side of a quadrilateral in a circle a perpendicular is drawn to the opposite side, and from the middle point of each diagonal to the other diagonal. Prove that the six perpendiculars pass through one point." (Mathematical Question 2027, solved.) Lady's and Gentleman's Diary, London, 162, 1865, p. 61.

40. Solar parallax, deduced from observations of Mars with equatorial instruments. Washington Obs'ns, 1863, Appendix A, pp. LX–LXIV.

41. New elements of Nemausa. Washington Obs'ns, 1863, Appendix B, pp. LXXXIII–XC.

42. Observations with the equatorial, 1863. Right ascensions and declinations of stars, asteroids and comets observed with the equatorial, 1863. [By James Ferguson and Asaph Hall. Professor Hall observed: comets 1863, I, 1863, II, 1863, IV; asteroids (14), (18), (39), (48), (49), (51), (55), (64), (79); Pleiades; double stars; occultations of stars by the moon.] Washington Obs'ns, 1863, pp. 217–284, 363–367.

1866.

43. Measures of the companion of Sirius . . . in 1866. [By S. Newcomb, A. Hall, J. R. Eastman, and H. P. Tuttle.] Astr. Nachr., 66, 1865-66, col. 381-382.

44. [On the determination of the solar parallax from equatorial observations of Mars.] Astr. Nachr., 68, 1866-67, col. 235–236.

45. At a given latitude (ϕ) two stars whose right ascensions and declinations are α, α', δ, δ', have the same altitude above the horizon. It is required to find the hour angle, and the conditions under which the phenomenon is possible. (Mathematical Question 2052.) Lady's and Gentleman's Diary, London, 163, 1866, p. 71; 164, 1867, p. 52.

46. Observations with the mural circle, 1864. [Observers: S. Newcomb, A. Hall, W. Harkness, and M. H. Doolittle.] Washington Obs'ns, 1864, pp. 105–191.

47. Observations with the equatorial, 1864. Right ascensions and declinations of stars, asteroids, and comets, observed with the equatorial, 1864. [By James Ferguson and Asaph Hall. Professor Hall observed: Comet 1863, VI; asteroids (1), (2), (3), (9), (12), (13), (16), (17), (19), (25), (27), (29), (34), (36), (37), (40), (42), (52), (60), (79), (81); cluster in Præsepe.] Washington Obs'ns, 1864, pp. 203-304, 377–389.

1867.

48. Observations of certain small planets, and of the stars which have been compared with Thisbe, made with the transit circle . . . during 1866 and 1867. [Observers: S. Newcomb, A. Hall, J. A. Rogers, and C. Thirion. Professor Hall observed asteroids (13), (22), (24), (28), (34), (50), (56), (71), (84), (85), (88), (89).] Astr. Nachr., 69, 1867, col. 151–156.

49. Remarks on hyperbolic movement. Messenger of Math., 4, 1868, pp. 106–107.

50. Gauss's proof that the middle points of the three diagonals of a complete quadrilateral lie in a right line. Messenger of Math., 4, 1868, p. 137.

51. Observations with the mural circle, 1865. [Observers: S. Newcomb, A. Hall, W. Harkness, J. A. Rogers, and M. H. Doolittle.] Washington Obs'ns, 1865, pp. 149–239.

52. Observations with the prime vertical transit instrument, 1865. [Observers: S. Newcomb, A. Hall, and W. Harkness.] Washington Obs'ns, 1865, pp. 241–249.

53. Observations with the equatorial, 1865. Right ascensions and declinations of stars, asteroids, and comets observed with the equatorial, 1865. [By James Ferguson and Asaph Hall. Professor Hall observed Comet 1864 IV, Faye's Comet; asteroids (5), (6), (8), (13), (14), (16), (24), (30), (31), (32), (34), (38), (46), (48), (49), (56), (57), (61), (63), (64), (67), (72), (78), (79), (85); Pleiades; cluster in Præsepe; occultations; and eclipse of the sun, October 18, 1865.] Washington Obs'ns, 1865, pp. 251–347, 429–435.

1868.

54. Observations of asteroids . . . during the year 1867 [on the transit circle. Observers: S. Newcomb, A. Hall, C. Thirion, and C. Abbe. Professor Hall observed asteroids (21), (24), (25), (29), (32), (37), (41), (42), (43), (45), (47), (51), (52), (59), (60), (64), (65), (68), (71), (79), (80), (82), (84), (85), (88), (92).] Astr. Nachr., 71, 1868, col. 161-170.

55. On the positions of the fundamental stars. Astr. Nachr., 71, 1868, col. 191-192.

56. Equatorial observations . . . [Brorsen's Comet, (95) Arethusa and (98) Ianthe.] Astr. Nachr., 72, 1868, col. 45-46.

57. It is required to find the mean or average distance from the vertex of a right cone (1) to all the points in the base of the cone, (2) to all the points in the solid content of the cone. (Mathematical Question 2085.) Lady's and Gentleman's Diary, London, 165, 1868, p. 95; 166, 1869, p. 79.

58. Observations with the transit circle, 1866. [Observers: S. Newcomb, A. Hall, J. A. Rogers, and C. Thirion.] Washington Obs'ns, 1866, pp. 1–194.

59. Observations with the prime vertical transit instrument, 1866. [Observers: S. Newcomb and A. Hall.] Washington Obs'ns, 1866, pp. 269–277.

60. Observations with the equatorial, 1866. Right ascensions and declinations of stars, asteroids, and comets, observed with the equatorial, 1866. [By James Ferguson, Asaph Hall, J. R. Eastman, and some of the occultations by H. P. Tuttle. Professor Hall observed Terpsichore (81), the cluster in Præsepe, and the companion of Sirius.] Washington Obs'ns, 1866, pp. 279–338, 409–413.

1869.

61. Equatorial observations . . . [Brorsen's Comet, Encke's Comet, and asteroids (26), (38), (43), (45), (54), (59), (60), (64), (76), (80), (92), (95), (101), (102), (106).] Astr. Nachr., 74, 1869, col. 71–78.

62. "Prove that $\frac{2}{n} = \frac{2^n}{n} - 2^{n-2} + \frac{n-3}{2} . 2^{n-4} - \frac{(n-4)(n-5)}{2.3} . 2^{n-6} + \frac{(n-5)(n-6)(n-7)}{2.3.4} \cdot 2^{n-8}$, &c., continued to 2^1 or 2^0, according as n is odd or even." (Mathematical Question 2089, answered.) Lady's and Gentleman's Diary, London, 166, 1869, p. 84.

63. Transformations of coördinates in Hansen's method of perturbations. Messenger of Math., 5, 1871, pp. 15–23.

64. Report on observations of the total eclipse of the sun, August 7, 1869. [At station near Plover Bay, Siberia.] Washington Obs'ns, 1867, Appendix II, pp. 197–218.

1870.

65. On the secular perturbations of the planets. Amer. Journ. Sci., 50, 1870, pp. 370–372.

66. Equatorial observations . . . [of Felicitas (109)]. Astr. Nachr., 75, 1869–70, col. 321–324.

67. Supplementary notes on the observations for magnetism and position, made by the U. S. Naval Observatory Expedition to Siberia to observe the solar eclipse of August 7, 1869. Astr. Nachr., 75, 1869-70, col. 323–328; Washington Obs'ns, 1867, Appendix II, pp. 215–218.

68. New elements of Terpsichore (81). Astr. Nachr., 76, 1870, col. 123–124.

69. Equatorial observations . . . [of the asteroids (51), (61), (70), (71), (110), (111)]. Astr. Nachr., 77, 1870–71, col. 15–16.

70. "If from any point P in the hypothenuse AB of a right-angled spherical triangle ABC, perpendiculars PE, PD are drawn to CB, CA, and if the segments CE, CD be denoted by α, β respectively, prove that $\frac{\tan \alpha}{\tan a} + \frac{\tan \beta}{\tan b} = 1$, where a, b are the sides." (Mathematical Question 2095, answered.) Lady's and Gentleman's Diary, London, 167, 1870, p. 75.

71. In Hansen's *Theory of perturbations* he makes use of what he calls the "arithmetico-geometrico mean." Thus, if A and B are two values, we have $\frac{1}{2}$ (A + B) = arith. mean = A_1; $\sqrt{AB}$ = geom. mean = B_1. Show that, by repeating this process on A_1 and B_1, and so on, the results A_n and B_n approach each other without limit. (Mathematical Question 2098, with answer.) Lady's and Gentleman's Diary, London, 167, 1870, p. 77.

72. Coördinates of a celestial body. Messenger of Math., 5, 1871, pp. 250–251.

73. Observations with the transit circle, 1867. [Observers: S. Newcomb, A Hall, J. A. Rogers, C. Thirion, and C. Abbe.] Washington Obs'ns, 1867, pp. 1–212.

74. Observations with the prime vertical transit instrument, 1867. [Observers: S. Newcomb, A. Hall, and C. Abbe.] Washington Obs'ns, 1867, pp. 303–305.

75. Catalogue of 151 stars in Præsepe. [Washington Observations, 1867] (Appendix IV). [Washington, 1870.] 38 pp., 29½ cm. Reviewed in Messenger of Math., 5, 1871, p. 151.

1871.

76. Transit of Venus in 1874. Amer. Journ. Sci., 1, 1871, pp. 307–308.

77. On the application of photography to the determination of astronomical data. Amer. Journ. Sci., 2, 1871, pp 25–30, 154. Abstract in Washington, Phil Soc. Bull., 1, 1871–74, pp. 28–29; Smithson. Misc. Coll., 20, 1881, Art. 1, pp. 28–29.

78. On the astronomical proof of a resisting medium in space. Amer. Journ. Sci, 2, 1871, pp. 404–408. Abstract in Astron. Soc. Month. Not., 33, 1872–73, pp. 239–242.

79. Observations and elements of Comet I, 1871. Astr. Nachr., 77, 1870–71, col. 319–320.

80. Ephemeris of Terpsichore, 1869. The Washington stars of comparison for 1868. Observations of Egeria, 1864. Photographic observations of the Venus transit in 1874. Astr. Nachr., 78, 1871-72, col. 167–168.

81. "Each of three circles (radii ρ_1 ρ_2 ρ_3) touches two sides of the triangle (a b c) and the nine-point circle; prove that $\frac{\rho_1}{r_1} + \frac{\rho_2}{r_2} + \frac{\rho_3}{r_3} = \frac{a^2 + b^2 + c^2}{(a + b + c)^2}$." (Mathematical Question 2113, answered.) Lady's and Gentleman's Diary, London, 168, 1871, pp. 77–78.

82. "The four sides of a quadrilateral are given; determine its form when the rectangle under the two diagonals is a maximum." (Mathematical Question 2117, answered.) Lady's and Gentleman's Diary, London, 168, 1871, p. 82.

83. Required, the integral of $\frac{dx}{\sin^2 x \cos^2 x}$. (Problem 89, with solution.) Schoolday Visitor, 15, 1871, pp. 164, 251.

84. [Introduction to the observations made with the 9.6-inch equatorial, 1868, 1869, 1870, 1871, 1873.] Washington Obs'ns, 1868, p. XL; 1869, p. XLIV; 1870, p. LXXXI; 1871, p. C; 1873, p. CI.

85. Observations with the transit circle, 1868. [Observers: S. Newcomb, A. Hall, W. Harkness, J. R. Eastman, C. Thirion, C. Abbe, and E. Frisby.] Washington Obs'ns, 1868, pp. 1-154.

86. Observations with the equatorial, 1868. [Brorsen's and Encke's comets, asteroids (26), (38), (43), (45), (54), (59), (60), (64), (76), (80), (92), (95), (98), (101), (102), (106), occultations of stars by the moon.] Washington Obs'ns, 1868, pp. 319-327.

87. Report on observations of the total solar eclipse of December 22, 1870. [Station at Syracuse, Sicily.] Washington Obs'ns, 1869, Appendix I, pp. 25–42. Quoted as to meteorological changes during totality and the appearance of the corona, in Astron. Soc. Mem., 41, 1879, pp. 213, 615, 643-644.

88. On the elements of the Comet I, 1871. Abstract. Washington, Phil. Soc. Bull., 1, 1871–74, p. 23; Smithson. Misc Coll., 20, 1881, Art. 1, p. 23.

89. On a curve of the fourth degree. ["Through the focus of an ellipse a right line is drawn, cutting the ellipse in the points D and E, and at the middle point of DE an indefinite right line is drawn perpendicular to DE. It is required to find the form and area of the curve that this perpendicular always touches"] Abstract. Washington, Phil. Soc Bull, 1, 1871–74, pp. 30–31; Smithson. Misc. Coll., 20, 1881, Art. 1, pp. 30–31. See No. 112

1872.

90. Equatorial observations . . . 1871. [Comets I, II, III, and IV, 1871; asteroids (10), (12), (19), (23), (26), (29), (31), (35), (41), (47), (48), (52), (54), (55), (59), (62), (64), (68), (71), (80), (81), (88), (92), (93), (95), (109), (113), (114), (116).] Astr. Nachr., 79, 1872, col. 97–112.

91. Observations of the companion of Sirius . . . Astr. Nachr., 79, 1872, col. 247–248.

92. Observations of Planet (121) . . . Astr. Nachr., 79, 1872, col. 367–368.

93. [Letter in regard to Professor Cayley's memoir, *On the determination of the orbit of a planet from three observations.*] Astr. Nachr., 80, 1872–73, col. 13–14.

94. Elements of Comet α, 1871, Winnecke. Astr. Nachr., 80, 1872–73, col. 29–32.

95. On an experimental determination of π. Messenger of Math., 2, 1873, pp. 113–114. See No. 105.

96. Historical note on the method of least squares. Nature, 6, 1872, pp. 101–102, 241–242. Title only in Washington, Phil. Soc. Bull., 1, 1871–74, p. 62; Smithson. Misc. Coll., 20, 1881, Art. 1, p. 62.

97. Hindrances to students of mathematics. Nature, 6, 1872, p. 351.

98. [November meteors observed at Washington.] Nature, 7, 1872–73, pp. 122–123.

99. Logarithmic tables [Remarks on]. Nature, 7, 1872–73, p. 222.

100. Observations with the transit circle, 1869. [Observers: S. Newcomb, A. Hall, W. Harkness, C. Thirion, and E. Frisby.] Washington Obs'ns, 1869, pp. 1–59.

101. Observations with the equatorial, 1869. [Asteroid (109) and occultations of stars by the moon. Professor Newcomb observed one of the occultations] Washington Obs'ns, 1869, pp. 233–236.

102. Zones of stars observed . . . with the mural circle in the years 1846, 1847, 1848, and 1849. By J. H. C. Coffin, T. J. Page, Charles Steedman. [Edited and introduction written by Asaph Hall.] (Washington Observations for 1869, Appendix II.) Washington, 1872. 25 + 331 pp. 30 cm.

103. Reports on observations of Encke's Comet during its return in 1871. By Asaph Hall and William Harkness. (Washington Observations for 1870, Appendix II.) Washington, 1872. 1 pl , 49 pp. 30 cm.

104. Zones of stars observed . . . with the meridian transit instrument in the years 1846, 1847, 1848, and 1849. By Reuel Keith, Mark H. Beecher, Joseph S. Hubbard, John J. Almy, and William A. Parker. [Edited and introduction written by Asaph Hall.] (Washington Observations for 1870, Appendix IV.) Washington, 1872. 13 + 271 pp. 30 cm.

105. On the experimental determination of the ratio of the circumference to the diameter, based on the principles of the calculus of probabilities. [Title only of paper read.] Washington, Phil. Soc. Bull., 1, 1871–74, p. 62; Smithson. Misc. Coll., 20, 1881, Art. 1, p. 62. See No. 95.

1873.

106. On the determination of longitudes by moon culminations. Astron. Soc. Month. Not., 33, 1872-73, pp. 465–466.

107. Elements of (124) Alceste, and observations of (129). Astr. Nachr., 81, 1873, col. 109–110.

108. Equatorial observations . . . [April-December, 1871. Asteroids (46), (64), (80), (98), (118), (119), (121), (122), (124), (128).] Astr. Nachr., 81, 1873, col. 171–176.

109. Positions of the principal stars derived from observations made at U. S. Naval Observatory by Prof. M. Yarnall in the years 1853 to 1860. Astr. Nachr., 82, 1873, col. 43–48.

110. Observations of Comet e, 1873, Henry . . . [with elements of its orbit]. Astr. Nachr., 82, 1873, col. 243–244.

111. New elements of (124) Alceste, with opposition ephemeris, 1873. Astr. Nachr., 82, 1873, col. 261-266.

112. "EG is a focal chord in an ellipse and MP a perpendicular to it at its middle point M. Show that the curve which the line MP always touches is a three-cusped curvilinear triangle, to which the axes of the ellipse are tangents, and that its area is to that of the ellipse as $e^6 : 1-e^2$, where e is the eccentricity." (Mathematical Question 3731, solved.) Educational Times, 25, 1872–73, p. 272; Math. Quest. from Educational Times, 19, 1873, pp. 28–29. See also No. 89.

113. On the motion of a particle toward an attracting center at which the force is infinite. Messenger of Math., 3, 1874, pp. 144–149.

114. Observations with the transit circle, 1870. [Observers: A. Hall, W. Harkness, J. R. Eastman, E. Frisby, and O. Stone.] Washington Obs'ns, 1870, pp. 1–87.

115. Observations with the equatorial, 1870. [Asteroids (51), (61), (70), (71), (109), (110), (111); occultations of stars by the moon, two of which were observed by Professor Newcomb.] Washington Obs'ns, 1870, pp. 255–259.

116. Observations with the transit circle, 1871. [Observers: A. Hall, W. Harkness, J. R. Eastman. E. Frisby, and O. Stone.] Washington Obs'ns, 1871, pp. 1–45.

117. Observations with the equatorial, 1871. [Comets I and II, 1871, and those of Encke and Tuttle; asteroids (10), (12), (19), (23), (26), (29), (31), (35), (41), (47), (48), (52), (54), (55), (59), (62), (64), (68), (71), (80), (81), (88), (92), (93), (95), (109), (113), (114), (116); occultations of stars by the moon. Some of the occultations were observed by S. Newcomb, A. N. Skinner, and H. P. Tuttle.] Washington Obs'ns, 1871, pp. 103–116.

118. Zones of stars observed . . . with the meridian circle in the years 1847, 1848, and 1849. By James Major, Lafayette Maynard, William B. Muse. [Edited and introduction written by Asaph Hall.] (Washington Observations for 1871, Appendix I.) Washington, 1873. 9 + 162 pp. 30 cm.

1874.

119. Comets and meteors. Analyst, Des Moines, 1, 1874, pp. 17–24.

120. The chief justice of a court makes a large number of decisions. Afterward it is found that 50 per cent. of these decisions are erroneous. Required, to determine the legal knowledge of the judge. (Problem 10, with solution.) [Moral for weather prophets, fortune-tellers, etc.] Analyst, Des Moines, 1, 1874, pp. 35, 71.

121. Besselian function. Analyst, Des Moines, 1, 1874, pp. 81–84.

122. "If $a, b, c, d, e, f, g, h, i, j, k$ be chords drawn from any point on the circumference of a circle to the eleven angles of an inscribed regular polygon of eleven sides, prove that $(a+k)(b+j)(c+i)(d+h)(e+g) = f^5$ . . . . (1)." (Problem 29, solved.) Analyst, Des Moines, 1, 1874, pp. 159–160.

123. Assuming the earth's orbit to be a circle, if a comet move in a parabola around the sun and in the plane of the earth's orbit, show that the comet cannot remain within the earth's orbit longer than 78 days (Problem 50) Analyst, Des Moines, 1, 1874, p. 212; 2, 1875, p. 30.

124. Equatorial observations . . . in 1873. [Comets a, b, c, d, e, and g, 1873; asteroids (9), (11), (21), (31), (33), (40), (43), (46), (49), (53), (58), (59), (60), (63), (67), (69), (71), (78), (81), (83), (92), (109), (112), (124), (129), (130), (131).] Astr. Nachr., 84, 1874, col. 17–28.

125. On the orbit of Alceste (124). Astr. Nachr., 84, 1874, col. 89–94.

126. [Correction to an observation of Alceste (124), December 10, 1874; position of comparison star for Electra (130).] Astr. Nachr , 84, 1874, col. 163–164.

127. Observations with the transit circle, 1872. [Observers: A. Hall. W. Harkness, J. R. Eastman, E. Frisby, and O. Stone.] Washington Obs'ns, 1872, pp. 1–159.

128. Observations with the equatorial, 1872. [Asteroids (46), (64), (80), (98), (118), (119), (121), (122), (124), (128); occultations; companion of Sirius, which was also observed by S. Newcomb and A. N. Skinner.] Washington Obs'ns, 1872, pp. 205-211.

129. Remarks on the method adopted in writing international telegrams. [Recommended the use of Littrow's system.] Washington, Phil. Soc. Bull., 1, 1871–74, p. 101; Smithson. Misc. Coll., 20, 1881, Art. 1, p. 101.

1875.

130. Photographic observations of the transit of Venus. Analyst, Des Moines, 2, 1875, pp. 89–90.

131. Into how many parts can n planes divide space? (Query.) Analyst, Des Moines, 2, 1875, p. 96.

132. If the parabolic orbits of two comets intersect the circular orbit of the earth in the same two points, then if t_1 and t_2 be the times in which the comets move from one point to the other, $(t_1 + t_2)^{\frac{2}{3}} + (t_1 - t_2)^{\frac{2}{3}} = \left(\frac{4}{3\pi}\right)^{\frac{2}{3}}$, a year being the unit of time. (Problem 82.) Analyst, Des Moines, 2, 1875, pp. 128, 158.

133. Note on the division of space. Analyst, Des Moines, 2, 1875, p. 140.

134. Ephemeris of Terpsichore (81) for the opposition, 1876. Astr. Nachr., 86, 1875, col. 3–6.

135. Observations made with the 26-inch equatorial . . . 1875. [Observers: S. Newcomb, A. Hall, and E. S. Holden. Article signed by A. Hall, who observed Oberon, Titania, Umbriel, and the companion of Sirius.] Astr. Nachr., 86, 1875, col. 321–328.

136. On the determination of the mass of Mars. Astr. Nachr., 86, 1875, col. 327–334.

137. On the Washington observations of Flora in 1873. Astr. Nachr., 86, 1875, col. 333–336.

138. Observations of the satellites of Saturn. Astr. Nachr., 87, 1875-76, col. 177–190.

139. Observations with the 9½-inch equatorial, 1873. [Observers: A. Hall and A. N. Skinner. Professor Hall observed comets *a*, *b*, *c*, *d*, *e*, *g*, 1873; occultations; companion of Sirius; asteroids (8), (9), (21), (31), (33), (40), (43), (46), (53), (58), (59), (60), (63), (67), (69), (71), (78), (81), (83), (109), (112), (124), (129), (130), (131).] Washington Obs'ns, 1873, pp. 159–173.

140. [Report on the operations of the Transit of Venus Party at Vladivostok, 1874.] Abstract. Washington, Phil. Soc. Bull., 2, 1874–78, pp. 32–33; Smithson. Misc. Coll., 20, 1881, Art. 2, pp. 32–33. A more extended account in the New York Daily Tribune, March 26, 1875.

1876.

141. Companions of Procyon. [By Asaph Hall and Edward S. Holden. Professor Hall failed to see them.] Amer. Acad. Proc., 11, 1875-76, pp. 185–190; Astr. Nachr., 87, 1875–76, col. 241–246.

142. Approximate quadrature. Analyst, Des Moines, 3, 1876, pp. 1–10. Abstract in Washington, Phil. Soc. Bull., 2, 1874–78, pp. 48–49; Smithson. Misc. Coll., 20, 1881, Art. 2, pp. 48–49.

143. Show that the determinant $\begin{vmatrix} a & b & c & d \\ b & a & d & c \\ c & d & a & b \\ d & c & b & a \end{vmatrix}$ is divisible by $(a+b)^2 - (c+d)^2$; and by $(a-b)^2 - (c-d)^2$. (Problem 109.) Analyst, Des Moines, 3, 1876, pp. 64, 89.

144. NOTE.—["That a revolving ellipsoid of three unequal axes can be in equilibrium" was not discovered by Mr. Ivory, but by C. G. J. Jacobi, whose note is published in Poggendorff's *Annalen*, 33, 1834, p. 229.] Analyst, Des Moines, 3, 1876, p. 127.

145. In a spherical triangle are given the sum of each angle and the side opposite, to solve the triangle. (Problem 121.) Analyst, Des Moines, 3, 1876, pp. 132, 157.

146. Integrate the expression $\frac{x.\ dx}{(x^3+8)\sqrt{(x^3-1)}}$. (Problem 132) [with note on Legendre's and Clausen's methods of solution]. Analyst, Des Moines, 3, 1876, pp. 163, 191; 4, 1877, p. 55.

147. Observations of the satellites of Neptune and Uranus [and the companion of Sirius]. Astr. Nachr., 88, 1876, col. 131–138.

148. Equatorial observations . . . [End of the eclipse of the sun, September 28, 1875. Occultations of Saturn, August 6 and September 2, 1876. By A. Hall, W. Harkness, E. S. Holden, and E. Frisby.] Astr. Nachr., 88, 1876, col. 297–298.

1877.

149. Elements of Hyperion, with ephemeris for 1877. Astr. Nachr., 90, 1877, col. 7–12.

150. Observations of the satellites of Saturn [June–December, 1876]. Astr. Nachr., 90. 1877, col. 129–138.

151. On the rotation of Saturn. Analyst, Des Moines, 4, 1877, pp. 36–42; Astr. Nachr., 90, 1877, col. 145–150. Synopsis in Astron. Soc. Month. Not., 38, 1877–78, pp. 209–210. Reviewed in Nature, 16, 1877, pp. 363–364.

152. The approximate value of the definite integral $\int_0^{\frac{\pi}{2}} \sqrt{\sin \phi}. \, d\phi$ is 1.198. Is there a convenient way of computing this numerical value? Query. Analyst, Des Moines, 4, 1877, p. 48. See No. 163.

153. P and Q being functions of x, find the conditions that the equation $y\,d\,y + (P - Qy)\,d\,x = 0$, is made integrable by the factor $\frac{y}{[y + f\,(x)]^n}$ and determine the form of $f\,(x)$. (Problem 160.) Analyst, Des Moines, 4, 1877, p. 64.

154. Differential equations of Problem 165. [The motion of two planets.] Analyst, Des Moines, 4, 1877, pp. 146–147.

155. Discovery of the satellites of Mars. [Letter to Mr. Glaisher.] Astron. Soc. Month. Not., 38, 1877–78, pp. 205–208.

156. On the appearance of Saturn's rings. Astr. Nachr., 90, 1877, col. 151–154. Abstract in Washington, Phil. Soc. Bull., 2, 1874–78, p. 94; Smithson. Misc. Coll., 20, 1881, Art. 2, p. 94.

157. Observations made with the 26-inch refractor . . . [Satellites of Neptune and Uranus, the companion of Sirius; by A. Hall and E. S. Holden. Double stars, by A. Hall.] Astr. Nachr., 90, 1877, col. 161-166.

158. Shadow of a planet. Astr. Nachr., 90, 1877, col. 305–314.

159. [Correction to the published observation of the satellites of Mars, made August 20, 1877; and on the effect of observing with a large refractor on estimates of magnitudes.] Astr. Nachr., 90, 1877, col. 361-362.

160. Observations of the satellites of Mars [August 11 to September 16, 1877]. Astr. Nachr., 91, 1877-78, col. 11–14.

161. On the position of the south-polar spot of Mars. Astr. Nachr., 91, 1877–78, col. 219–224.

162. [On the stars in the halo of light surrounding Sirius.] Astr. Nachr., 91, 1877–78, col. 223–224.

163. Find the approximate value of the integral $\int_0^{\frac{1}{2}\pi} (\sin\,\theta)^{\frac{1}{2}}\ d\theta$. (Mathematical Question 5249.) Educational Times, 30, 1877–78, pp. 21, 91; Math. Quest. from Educational Times, 28, 1877, p. 19. See No. 152.

164. [Condition of the atmosphere in regard to astronomical observations at the Old Naval Observatory. Letter to the Superintendent, dated September 8, 1877.] In Reports on the removal of the United States Naval Observatory; Rear-Admiral John Rodgers. Washington, 1877, p. 9; also in Report Sec. Navy, 1877, p. 313.

165. [Letter to the Superintendent in relation to change of organization of the Naval Observatory, dated November 24, 1877. Signed by M. Yarnall, A. Hall, and others.] In Reports on the removal of the United States

Naval Observatory, Rear Admiral John Rodgers. Washington, 1877, pp. 17–18; Report Sec. Navy, 1877, pp. 321–322.

166. [Results of measures of Sirius and companion, March 25 and 26, 1874, with the 26-inch equatorial.] Washington Obs'ns, 1874, p. 290.

167. Bright spot which had recently become visible on the ball of Saturn. Abstract. Washington, Phil. Soc. Bull., 2, 1874–78, p. 102; Smithson. Misc. Coll., 20, 1881, Art. 2, p. 102.

1878.

168. [Circular letter, signed by M. Yarnall, A. Hall, and others, addressed to the members of the National Academy of Sciences, and taking exception to certain reflections upon the professional astronomers of the Naval Observatory, contained in a circular previously received by members of the Academy.] Washington, D. C., January 24, 1878, 1 p., 25½ cm.

169. Report of the committee [of the National Academy of Sciences] on proposed changes in the Nautical Almanac. [Signed by J. E. Hilgard, J. H. C. Coffin, A. Hall, and others.] American Ephemeris and Nautical Almanac, 1882, pp. 518–519.

170. Observations of the brightness of the satellites of Uranus. [By A. Hall and E. S. Holden.] Amer. Journ. Sci., 15, 1878, pp. 195–197.

171. Center of gravity of the apparent disk of a planet. Analyst, Des Moines, 5, 1878, pp. 44–45; Astron. Soc. Month. Not., 38, 1877–78, pp. 122–123.

172. Given $x = a \cos A \pm r_1$, $y = a \sin A \pm r_2$, where r_1 and r_2 are the probable errors of x and y. Required the probable errors of a and A. (Problem 201.) Analyst, Des Moines, 5, 1878, pp. 64, 92.

173. Observations of stars around the ring-nebula in Lyra. Astr. Nachr., 92, 1878, col. 27–28.

174. Names [and approximate elements] of the satellites of Mars. Astr. Nachr., 92, 1878, col. 47–48.

175. Corrections to observations of comets. [Tuttle's Comet and Comet *c*, 1873, Borrelly.] Astr. Nachr., 92, 1878, col. 365-366.

176. Observations with the 26-inch refractor . . . [Satellites of Saturn; disappearance of the ring; satellites of Uranus; Venus; transit of Mercury, May 6, 1878; companion of Sirius. Of these the observations of Oberon and Titania, two observations of Mimas, and six of the companion of Sirius were made by Professor Holden.] Astr. Nachr., 93, 1878, col. 65–70.

177. Mathematical Question 5522. [Statement not accessible.] Educational Times, 31, 1878–79, p. 21.

178. Mathematical Question 5596. [Statement not accessible.] Educational Times, 31, 1878–79, p. 113.

179. [Introduction to the observations made with the 26-inch equatorial, 1875–1890.] Washington Obs'ns, 1875, pp. LXXXIII–LXXXIV; 1876, pp. XCI–XCIII; 1877, p. LXXXV; 1878, p. LXXI; 1879, p. LXXI; 1880, p. LXXI; 1881, p. LXXV; 1882, p. LXIII; 1883, p. LXXIX;

1884, p. XCIII; 1885, p. CIII; 1886, p. XCVII; 1887, p. LXXXVII 1888, p. A91; 1889, p. LXVII; 1890, p. LI.

180. Observations made with the 26-inch equatorial, 1875. [Observers: S. Newcomb, A. Hall, E. S. Holden, C. L. Doolittle, D. P. Todd, and H. P. Tuttle. Professor Hall observed the satellites of Saturn, of Uranus, and of Neptune; diameter of Jupiter, diameters of the rings of Saturn, companion of Sirius, double stars, and nebulæ.] Washington Obs'ns, 1875, pp. 283–366.

181. Observations of the solar eclipse September 28, 1875 [made with the 9.6-inch equatorial. A. Hall, observer; H. M. Paul, recorder]. Washington Obs'ns, 1875, p. 372.

182. Observations and orbits of the satellites of Mars; with data for ephemerides in 1879. Washington, 1878. 46 pp. 29½ cm. A few copies of this paper were bound in with the Washington Observations for 1875; the others were issued separately. There is an abridged French translation by Paul Guieysse, in Liouville, Journ. Math., 5, 1879, pp. 143-162. The discovery of the satellites of Mars was officially announced in the "Letter to the Hon. R. W. Thompson, Secretary of the Navy . . . [signed by] John Rodgers, Rear-Admiral and Superintendent." (Washington, August 21, 1877.) 3 pp., 25½ cm. Reprinted in the Amer. Journ. Sci., 14, 1877, pp. 326–327; Astron. Soc. Month. Not., 37, 1876–77, pp. 443-445; Astr. Nachr., 90, 1877, col. 273-276. A copy of the dispatch sent out by the Smithsonian Institution is contained in the above letter; a German translation, in the Astr. Nachr., 90, 1877, col. 189–190, with later data in English, col. 239-240; a French translation in Paris, Acad. Sci. Compt. Rend., 85, 1877, p. 437.

183. Results of his search for satellites of Mars. Abstract. Washington, Phil. Soc. Bull., 2, 1874–78, p. 186; Smithson. Misc. Coll., 20, 1881, Art. 2, p. 186.

184. [Remarks on planetary motions.] Washington, Phil. Soc. Bull., 2, 1874–78, pp. 188, 189, 192; Smithson. Misc. Coll., 20, 1881, Art. 2, pp. 188, 189, 192.

185. [Remarks on the transit of Mercury, 1878.] Washington, Phil. Soc. Bull., 2, 1874–78, p. 199; Smithson. Misc. Coll., 20, 1881, Art. 2, p. 199.

186. On the supposed discovery of a trans-Neptunian planet at the U. S. Naval Observatory in 1850. Washington, Phil. Soc. Bull., 3, 1878–80, pp. 20–21; Smithson. Misc. Coll., 20, 1881, Art. 3, pp. 20–21.

187. Report on the orbits of the satellites of Mars. [Title only.] Washington, Proc. Nation. Acad., 1, 1863–94, p. 129; Report, 1878–79, p. 2.

1879.

188. On the observations of double stars. Amer. Assoc. Proc., 28, 1879, pp. 65–73.

189. If in the plane xy the directions of the forces P and P^1 make with the axis of x the angles a and a^1, and the direction of their resultant the angle A, and if we denote by p, p^1, and r the perpendiculars from the origin on

these directions, we have the relation $r \sin (a^1 - a) + p \sin (A - a^1) + p^1 \sin (a - A) = 0$. (Problem 248, with solution.) Analyst, Des Moines, 6, 1879, pp. 31, 62.

190. Stellar parallax. Analyst, Des Moines, 6, 1879, pp. 33–40.

191. When we descend below the surface of the earth, does the earth's attractive force increase or diminish? (Query 1.) Analyst, Des Moines, 6, 1879, pp. 64, 85.

192. "If the given quantities x_1, x_2, x_3, x_4 have the probable errors r_1, r_2, r_3, r_4, respectively, find the probable error r of the quantity x when $x_1 : x_2 : : x_3 + x : x_4 + x$." (Problem 256, solved.) Analyst, Des Moines, 6, 1879, p. 93.

193. Find the moments of inertia of an elliptic disk about a straight line in the plane of the disk and parallel to (1) the axis of x, (2) the axis of y, the equation of the disk being $ax^2 + 2\,bxy + cy^2 + 2\,dx + 2\,ey + f = 0$. (Problem 275, with solution.) Analyst, Des Moines, 6, 1879, pp. 128, 158–159; also proposed as Mathematical Question 6041, in the Educational Times, 32, 1879, pp. 243, 268; Math. Quest. from Educational Times, 32, 1879, p. 50.

194. Motion of a satellite. Analyst, Des Moines, 6, 1879, pp. 129–139.

195. On a theorem of Lambert's. Analyst, Des Moines, 6, 1879, pp. 171–173.

196. "If from any point in the plane of a parallelogram perpendiculars are let fall on the diagonal and on the two sides that contain this diagonal, the product of the diagonal by its perpendicular is equal to the sum of the products of the sides by their respective perpendiculars if the point falls outside of the parallelogram, or to their difference if it lies within the parallelogram." Varignon's Theorem: *Mécanique analytique*, Tome 1, p. 13. (Problem 283, selected by Professor Hall.) Analyst, Des Moines, 6, 1879, p. 190; Lagrange quoted, 7, 1880, p. 27.

197. Extracts from a letter to the Astronomer Royal. [On the elements of some of the planets.] Astron. Soc. Month. Not., 39, 1878–79, pp. 373-374.

198. Note on Hyperion. Astron. Soc. Month. Not., 39, 1878–79, p. 517.

199. Observations of Hyperion. Astr. Nachr., 94, 1878–79, col. 221–222.

200. [Letter to the editor stating that an observation of the companion of Sirius made at the Naval Observatory, 1873, November 29, which gives $p = 59°4$ $s = 12''27$ had been erroneously ascribed to the writer, who wished to say, therefore, that the observation was not made by him.] Astr. Nachr., 94, 1878–79, col. 383–384.

201. Motion of Hyperion. Astr. Nachr., 95, 1879, col. 109–112.

202. Note on Saturn. Astr. Nachr., 95, 1879, col. 191–192.

203. Observations of the companion of Sirius. [By A. Hall and E. S. Holden.] Astr. Nachr., 95, 1879, col. 329–330.

204. Mathematical Question 5958. [Statement not accessible.] Educational Times, 32, 1879, p. 152.

205. Mathematical Question 6068. [Statement not accessible.] Educational Times, 32, 1879, p. 269.

206. Mathematical Question 6119. Educational Times, 32, 1879, p. 316. Same as No. 221.

207. Trans-Neptunian planet. Nature, 19, 1878–79, p. 481.

208. Les satellites de Mars en 1879. Paris, Acad. Sci. Compt. Rend., 89, 1879, pp. 776–778.

209. Report on telescopic observations of the transit of Mercury, May 5–6, 1878. Washington Obs'ns, 1876, Appendix II, pp. 3–7.

210. On the satellites of Saturn. [Hyperion and Titan.] Abstract. Washington, Phil. Soc. Bull., 3, 1878–80, p. 26; Smithson. Misc. Coll., 20, 1881, Art. 3, p. 26.

211. Notes on the orbits of Titan and Hyperion. Abstract. Washington, Phil. Soc. Bull., 3, 1878–80, pp. 40–41; Smithson. Misc. Col., 20, 1881, Art. 3, pp. 40–41.

212. Satellites of Mars in 1879. [Title only.] Washington, Proc. Nation. Acad., 1, 1863–94, p. 166; Report, 1879–80, p. 6. See Nos. 208, 218.

1880.

213. [On the progress of astronomy.] Address, Vice-President Section A. Amer. Assoc. Proc., 29, 1880, pp. 99–114; Nature, 22, 1880, pp. 570–574; Observatory, London, 3, 1879–80, pp. 594–601, 640–645; Science, Michels, 1, 1880, pp. 123–127. French translation in Les Mondes, 54, 1881, pp. 26–33.

214. Note on the companion of Sirius. Amer. Journ. Sci., 19, 1880, pp. 457–458.

215. Given, the common astronomical equations: tang $(\lambda - \Omega) = \cos i$ tang u, $\sin \beta = \sin i \sin u$, eliminate u, and show in this manner that tang $\beta =$ tang $i \sin (\lambda - \Omega)$. (Problem 295, with solution.) Analyst, Des Moines, 7, 1880, pp. 31, 62.

216. Parallel chords in an ellipse. Analyst, Des Moines, 7, 1880, pp. 82–83.

217. (1) If v be the potential function, we have the equation given by Laplace, $\frac{d^2v}{dx^2} + \frac{d^2v}{dy^2} + \frac{d^2v}{dz^2} = 0$, which holds for a point outside the attracting body. For a point inside this body we have the equation given by Poisson, $\frac{d^2v}{dx^2} + \frac{d^2v}{dy^2} + \frac{d^2v}{dz^2} = -4\pi\rho$. What is the value of the right-hand side of this equation for a point on the surface of the attracting body? Moigno says, "In this case the expression will have in reality eight distinct values." *Statics*, p. 460.

(2.) Given a hemispherical dome turning about a pin at the top, and having a slit extending from the horizon to the zenith, can a telescope be placed inside this dome in such a position that every point of the heavens can be seen through the telescope? (Query.) Analyst, Des Moines, 7, 1880, pp. 135, 161–162.

218. Observations of the satellites of Mars. Astron. Soc. Month. Not., 40, 1879–80, pp. 272–283.

219. Note on β Leporis. Astr. Nachr., 96, 1879–80, col. 239–240.

220. Observations of the companion of Sirius. Astr. Nachr , 97, 1880, col. 319–320.

221. If Δ_1, Δ_2, Δ_3, Δ_4 be the lengths of four parallel chords in an ellipse, and if (1.2), (1.3), (1.4), (2.3), (2.4), (3.4) denote the distances between these chords, prove that $+ (2.3)\ (2.4)\,.\,(3.4)\,.\,\Delta_1{}^2 - (1.3)\ (1.4)\ (3.4)\ \Delta_2{}^2 + (1.2)\ (1.4)\,.\,(2.4)\,.\,\Delta_3{}^2 - (1.2)\ (1.3)\ (2.3)\ \Delta_4{}^2 = 0$. (Mathematical Question 6119, selected from Savary in the *Conn. des Temps*, 1830, Add. p. 65.) Educational Times, 33, 1880, p. 21. Same as 206.

222. "If two bodies revolve about a center, acted upon by a force proportional to the distance from the center, and independent of the mass of the attracted body, prove that each will appear to the other to move in a plane, whatever be the mutual attraction." (Mathematical Question 5968, solved.) Educational Times, 33, 1880, p. 309.

223. Notes of observations of contact [made at Vladivostok]. In observations of the transit of Venus, December 8–9, 1874, made and reduced under the direction of the Commission created by Congress; edited by Simon Newcomb. Part I. Washington, 1880, pp. 145–146.

224. Comets [visible in October, 1880]. Science, Michels, 1, 1880, p. 214.

225. Comet *e*, 1880. Science, Michels, 1, 1880, p. 259.

226. Tycho Brahe's new star. Science, Michels, 1, 1880, pp. 274–275.

227. Swift's Comet. Science, Michels, 1, 1880, p. 283.

228. Illustration. [In regard to the controversy between Professor Tait and Mr. Herbert Spencer.] Science, Michels, 1, 1880, pp. 309–310.

229. Tempel-Swift Comet. Science, Michels, 1, 1880, p. 330.

230. Observations made with the 26-inch equatorial, 1876. [Observers: A. Hall, E. S. Holden, and others. Professor Hall discovered and observed the white spot on Saturn, observed the satellites of Saturn, of Uranus, and of Neptune, occultations of Saturn, the companion of Sirius, double stars, &c.] Washington Obs'ns, 1876, pp. 309–400.

231. Report on the total solar eclipse of July 29, 1878. [As chief of party at La Junta, Colorado.] Washington Obs'ns, 1876, Appendix III, pp. 251–257.

1881.

232. A comet moves about the sun in a given parabolic orbit. Find the right ascension and declination of the point on the heavens towards which the comet approaches as it recedes from the sun and the earth. (Problem 338.) Analyst, Des Moines, 8, 1881, p. 31; Question 6660, Educational Times, 34, 1881, p. 123.

233. Notes on Gauss' *Theoria motus*. Analyst, Des Moines, 8, 1881, pp. 83–88.

234. Given $z = a \sin (x + \alpha) + b \sin (y + \beta)$, reduce z to the form $z = \mathrm{D} \sin \frac{1}{2} (x + \alpha + y + \beta + \delta)$. (Problem 347.) Analyst, Des Moines, 8, 1881, pp. 103, 130; Question 6740, Educational Times, 34, 1881, p. 171; 37, 1884, p. 329.

235. "Observations on the motions of the sun-spots have also established the fact that the sun is not a fixed body, around which the earth revolves, but that it has a motion of its own through space." *Physiography*, by T. H. Huxley, 2d ed., p. 365. How can the above fact be determined by observations of the sun-spots? (Query.) Analyst, Des Moines, 8, 1881, p. 104; Science, Michels, 2, 1881, p. 215.

236. "Given the angles A, B and C of a plane triangle, and $d \log a$, $d \log b$, and $d \log c$; a, b, c being the sides respectively. What are the corresponding values dA, dB, and dC expressed in seconds of arc?" (Problem 358, solved.) Analyst, Des Moines, 8, 1881, p. 165.

237. Secular displacement of the orbit of a satellite. Analyst, Des Moines, 8, 1881, pp. 177–187.

238. Centrifugal tides. Analyst, Des Moines, 8, 1881, pp. 188–189.

239. [Obituary notice of Dr. Carl Rudolf Powalky, 1817–1881.] Astr. Nachr., 100, 1881, col. 159–160.

240. Observations of comets. [Faye's Comet and Comet *e*, 1880.] Astr. Nachr., 100, 1881, col. 273–278.

241. Data for ephemerides of the satellites of Mars in the opposition of 1881. Astr. Nachr., 100, 1881, col. 277–280; Science, Michels, 2, 1881, p. 543.

242. Observations of Hyperion [with ephemeris]. Astr. Nachr., 100, 1881, col. 279–282, 351.

243. Satellites of Mars in 1881. Astr. Nachr., 101, 1881–82, col. 121–122.

244. Sobre la densidad de Saturno. Cronica Científica, Barcelona, 4, 1881, p. 90.

245. Notes on double stars [ϵ and α Lyræ]. Observatory, London, 4, 1881, pp. 281–282.

246. Lunar eclipse, June 11, 1881. [Observations.] Observatory, London, 4, 1881, p. 282.

247. Brightness of the satellites of Mars. Observatory, London, 4, 1881, p. 361.

248. [Partial solar eclipse of December 31, 1880. Observation of last contact.] Science, Michels, 2, 1881, p. 8.

249. Intra-Mercurial planets. Science, Michels, 2, 1881, pp. 202–203.

250. Satellites of Mars. [Observation made November 20, 1881.] Science, Michels, 2, 1881, p. 557.

251. Observations made with the 26-inch equatorial, 1877. [Observers: A. Hall and E. S. Holden. Professor Hall discovered and observed the satellites of Mars; observed the satellites of Saturn and of Neptune, Saturn's ring, white spot on the ball of Saturn, companion of Sirius, double stars, Ring nebula, &c.] Washington Obs'ns, 1877, pp. 183–231.

252. Observations of double stars . . . [Part I, 1863, 1875–79. Washington Observations, 1877, Appendix VI.] Washington, 1881. 144 pp., 29½ cm. Reviewed by H. A. Newton, Amer. Journ. Sci., 22, 1881, pp. 84–85; by E. B. Knobel, Astron. Soc. Month. Not., 42, 1881–82, pp. 179–180; Nature, 25, 1881–82, p. 122.

1882.

253. [Resolutions upon the death of Rear Admiral John Rodgers, adopted by the gentlemen attached to the U. S. Naval Observatory and signed by W. T. Sampson, Asaph Hall, and others.] Washington, May 10, 1882. 1 p., engraved, 33 cm.

254. Parallax of α Lyræ and 61 Cygni. Amer. Assoc. Proc., 31, 1882, pp. 93–99; Sidereal Messenger, 2, 1883–84, pp. 1–8.

255. "Show that $\int_0^{\frac{1}{2}\pi} \frac{\sqrt{(1-c)}.\,d\theta}{1-c\cos^n\theta} = \frac{\pi}{\sqrt{(2n)}}$ when c is indefinitely nearly equal to unity, n being a positive quantity." (Problem 365, solved.) Analyst, Des Moines, 9, 1882, p. 26.

256. "Show that $\int_0^a dx \int_0^x \phi\,(x, y)\,.\,dy = \int_0^a dy \int_y^a \phi\,(x, y)\;dx$."— Dirichlet's theorem. (Problem 384, selected.) Analyst, Des Moines, 9, 1882, pp. 32, 62.

257. Note on Problem 374.—["Prove, 1st, that the probable value of any tabular value in a table of logarithms, trigonometric functions, etc., is 0.25 of a unit of the last decimal place, supposing this place correct to the nearest unit; 2d, that the average of the squares of probable errors of interpolated values depending on first differences only is $\frac{2}{3}$ $(0.25)^2$."] Analyst, Des Moines, 9, 1882, p. 48.

258. Correction of Barlow's *Tables* . . . De Morgan's edition, London, 1875. Analyst, Des Moines, 9, 1882, p. 64.

259. Given $\log 91 = 1.95904 \pm r$, $\log 92 = 1.96379 \pm r$, find log 91.5 to five decimals, by simple proportion from the difference, and find the probable error of this logarithm. (Problem 391, with solution.) Analyst, Des Moines, 9, 1882, pp. 64, 94; also proposed as Problem 7030, Educational Times, 35, 1882, p. 129.

260. In a plane passing through the center of the sun, 12 right lines are drawn from this center, making an angle of 30° with each other. On each of these lines three homogeneous spherical bodies are placed at distances respectively of 10, 20, and 30 from the center of the sun, the distance from the earth to the sun being the unit of distance. The mass of each of these bodies being equal to that of the sun, what will be the velocity of a particle that starts from an infinite distance and moves in a right line towards the center of the sun, and perpendicularly to the plane of the bodies, when the particle is at a distance of 0.01 from the center of the sun, the law of attraction being that of Newton? (Problem 400, with solution.) Analyst, Des Moines, 9, 1882, pp. 96, 126.

261. "Given $\phi\,(x^2)\,\phi\,(y^2) = \phi\,(x'^2)\,\phi\,(y'^2)$ and $x^2 + y^2 = x'^2 + y'^2$, to determine the form of the function denoted by ϕ." (Problem 397, solved.) Analyst, Des Moines, 9, 1882, pp. 123–124.

262. Density of the earth. Analyst, Des Moines, 9, 1882, pp. 129–132.

263. "A smooth horizontal disk revolves with the angular velocity $\sqrt{\mu}$ about a vertical axis, at which is placed a material particle attracted to a certain point of the disk by a force whose acceleration is $\mu \times$ distance;

prove that the path on the disk will be a cycloid.—Routh's *Rigid dynamics*, p. 163." (Problem 396, solved.) Analyst, Des Moines, 9, 1882, p. 153.

264. Transform the definite integral $\int_b^a \phi(x) \,. dx$, so that the limits of integration shall be m and n. (Problem 420.) Analyst, Des Moines, 9, 1882, p. 195; 10, 1883, p. 29.

265. Conjunctions of the interior satellites of Saturn. Astron. Soc. Month. Not., 42, 1881–82, p. 308.

266. Observations of the companion of Sirius . . . [Observers: A. Hall and E. Frisby.] Astron. Soc. Month. Not., 42. 1881–82, pp. 323–324.

267. Note on meteoric astronomy. Astr. Nachr., 101, 1881–82, col. 351–352.

268. Note on double stars. Astr. Nachr., 102, 1882, col. 91–92.

269. The Greenwich observations of γ Draconis, made with the reflex zenith tube. Astr. Nachr., 102, 1882, col. 143–144.

270. Observations of the satellites of Mars in the opposition of 1881. Astr. Nachr., 102, 1882, col. 217–220.

271. Superior conjunctions of Hyperion, 1882. Astr. Nachr., 102, 1882, col. 383–384.

272. Note on ϵ Lyræ. Observatory, London, 5, 1882, p. 290.

273. Sur l'orbite de Japhet. Paris, Acad. Sci. Compt. Rend., 95, 1882, pp. 168–171.

274. Note on o^2 Eridani. Sidereal Messenger, 1, 1882–83, p. 94.

275. Observations with the 26-inch equatorial, 1878. [Observers: A. Hall and E. S. Holden. Professor Hall observed Umbriel, satellites of Saturn, Saturn's rings, double stars, &c.]—Results of observations made with the 26-inch equatorial, 1878. Washington Obs'ns, 1878, pp. 63–98.

276. Parallax of α Lyræ and 61 Cygni. [Washington Observations for 1879, Appendix I.] Washington, 1882. 64 pp., 29½ cm. Reviewed in L'Astronomie, 4, 1885, p. 311; Bul. Astr., Paris, 1, 1884, pp. 198–199; Copernicus, 3, 1883–84, pp. 188–189; by R. S. Ball, Observatory, 6, 1883, pp. 60–61.

1883.

277. Kepler's problem. Analyst, Des Moines, 10, 1883, pp. 65–66. Reviewed in Sidereal Messenger, 2, 1883–84, p. 132.

278. "A lamina is bounded on two sides by two similar ellipses, the ratio of the axes in each being m, and on the other two sides by two similar hyperbolas, the ratio of the axes in each being n. These four curves have their principal diameters along the co-ordinate axes. Prove that the product of inertia about the co-ordinate axes is $\frac{(\alpha^2 - \alpha'^2)\ (\beta^2 - \beta'^2)}{4\ (m^2 + n^2)}$ where $\alpha\alpha'$, $\beta\beta'$ are the semi-major axes of the curves.—Routh's *Rigid dynamics*." (Problem 440, solved.) Analyst, Des Moines, 10, 1883, p. 127.

279. "Given five equations, $x_1^2 + x_2^2 + x_3^2 = 3\beta^2$, $y_1^2 + y_2^2 + y_3^2 = 3\alpha^2$, $x_1y_1 + x_2y_2 + x_3y_3 = 0$, $x_1 + x_2 + x_3 = 0$, $y_1 + y_2 + y_3 = 0$. Eliminate x_2y_2 x_3y_3, and show that $\alpha^2 x_1^2 + \beta^2 y_1^2 = 2\alpha^2\beta^2$ —Routh's *Dynamics*, 4th edition, Article 38." (Problem 444, solved.) Analyst, Des Moines, 10, 1883, p. 157.

280. Observations . . . [Conjunctions of the satellites of Saturn, the companion of Sirius, of which eight of the former and seven of the latter were made by Professor Frisby.—Note on the Great Comet, *b*, 1882.] Astron. Soc Month. Not., 43, 1882–83, pp. 330–331.

281. Note on the mass of Saturn. Astron. Soc. Month. Not., 44, 1883–84, pp. 6–8. Synopsis in Astron. Reg., 21, 1883, pp. 276–277; noticed in Nature, 29, 1883–84, p. 185.

282. [Error in temperature coefficient for the micrometer screw of the Washington 26-inch refractor, which was applied in reducing the observations for the parallax of α Lyræ and 61 Cygni.] Astr. Nachr , 105, 1883, col. 271–272.

283. Observations of the companion of Sirius. [February and March, 1883. By A. Hall and E. Frisby.] Sidereal Messenger, 2, 1883–84, p. 127.

284. Constant of aberration and the solar parallax. Sidereal Messenger, 2, 1883–84, pp. 165–169.

285. Observations made with the 26-inch equatorial, 1879. [Observers: A. Hall and E. S. Holden. Professor Hall observed Ariel, Titan, Hyperion, Iapetus, satellites of Mars, double stars.]—Results of observations with the 26-inch equatorial, 1879. Washington Obs'ns, 1879, pp. 83–142.

286. Observations of the Great Comet of 1882. Washington Obs'ns, 1880, Appendix I, pp. 23–24, 29.

287. [On the science of mathematics and the "advantages of putting a question in a mathematical form."] Inaugural address of the Chairman of the Mathematical Section. Washington, Phil. Soc. Bull., 6, 1883, pp. 117–119; Smithson. Misc. Coll., 33, 1888, Art. 1, pp. 117–119.

288. [Criteria which have been proposed for the rejection of doubtful observations.] Abstract. Washington, Phil. Soc. Bull., 6, 1883, pp. 155–156; Smithson. Misc. Coll., 33, 1888, Art. 1, pp. 155-156.

1884.

289. Determination of the mass of a planet from the relative position of two satellites. Ann. Math., 1, 1884–85, pp. 1–4. Abstract in Washington, Phil. Soc. Bull., 6, 1883, pp. 132–133; Smithson. Misc. Coll., 33, 1888, Art. 1, pp. 132–133.

290. A horizontal wind blows against a hemispherical dome of radius R^f. The pressure exerted by the wind on a plane surface normal to its direction is P pounds to the square foot; on a surface oblique to its direction the pressure exerted is normal, but it is reduced in the ratio $1 : 1 + \frac{1}{2}\tan^2 i$, where i is the angle of incidence. (Poncelet, *Mécanique industrielle*, 403.) It is required to find the magnitudes and the points of application of the horizontal and vertical components of the resultant wind-pressure. (Exercise 1, solved.) Ann. Math., 1, 1884–85, pp. 44–47.

291. The result $-\frac{p^2q^2+4p^3r-8q^3+2pqr+9r^2}{(r-pq)^2}$ is given as the equivalent of the function $\left(\frac{\beta-\gamma}{\beta+\gamma}\right)^2+\left(\frac{\gamma-\alpha}{\gamma+\alpha}\right)^2+\left(\frac{\alpha-\beta}{\alpha+\beta}\right)^2$, where α, β, γ are roots of the cubic $x^3+px^2+qx+r=0$. Is this result correct? (Exercise 12.) Ann. Math., 1, 1884–85, pp. 48, 88, 112–113.

292. In his work *Die lineale Ausdehnungslehre, ein neuer zweig der Mathematik*, p. 65, Grassmann says: "Lagrange führt in seiner *Méc. anal.*, p. 14 der neuen Ausgabe, einen Satz von Varignon an, dessen er sich zur Verknupfung der verschiedenen Principien der Statik bedient. * * * * Dieser Satz ist, wie sich sogleich zeigen wird, unrichtig." In what way is this theorem incorrect as used by Todhunter and others? (Exercise 17.) Ann. Math., 1, 1884–85, pp. 71, 92.

293. Observations . . . [Conjunctions of the satellites of Saturn, satellites of Mars, and companion of Sirius.] Astron. Soc. Month. Not., 44, 1883–84, pp. 358–361.

294. Motion of Hyperion. Astron. Soc. Month. Not., 44, 1883–84, pp. 361–365. Abstract in Science, 4, 1884, pp. 155–156.

295. Uniform ephemeris of the clock stars. Astr. Nachr., 109, 1884, col. 145–146; Observatory, London, 7, 1884, pp. 220–221. Abstract in Sidereal Messenger, 3, 1884, p. 180.

296. Note on the latitude of the Naval Observatory. Astr. Nachr., 110, 1884–85, col. 129–132.

297. Lettre. [Les éphémérides de Mimas et Hypérion par M. Marth.—La limite supérieure de la masse de Titan par M. Tisserand.] Bul. Astr., Paris, 1, 1884, p. 478.

298. If a planet be spherical and ϕ be the angle at the planet between the earth and the sun and a the radius of the sphere, prove that the distance of the centroid of the planet's apparent disk from its true center will be $\frac{8a}{3\pi}\sin^2\frac{1}{2}\phi$ when the planet is gibbous, $\frac{8a}{3\pi}\cos^2\frac{1}{2}\phi$ when the planet is crescent. (Mathematical Question 5522.) Educational Times, 37, 1884, p. 210.

299. Observations of the companion of Sirius. Sidereal Messenger, 3, 1884, p. 179.

300. Satellites of Saturn. [Commends Marth's *Ephemeris*.] Sidereal Messenger, 3, 1884, p. 318.

301. Observations made with the 26-inch equatorial, 1880. [Observers: A. Hall, E. S. Holden, and E. Frisby. Professor Hall observed Titan, Hyperion, Iapetus, double stars, &c.]—Results of observations with the 26-inch equatorial, 1880. Washington Obs'ns, 1880, pp. 91–110.

302. Formulæ for computing the position of a satellite. Washington, Phil. Soc. Bull., 7, 1884, pp. 93–101; Smithson. Misc. Coll., 33, 1888, Art. 2, pp. 93–101.

303. Motion of Hyperion. [Title only.] Washington, Proc. Nation. Acad., 1, 1863–94, p. 250; Report . . . 1884, p. 12. See No. 294.

1885.

304. Variations of latitude. Amer. Journ. Sci., 29, 1885, pp. 223–227; Observatory, London, 8, 1885, pp. 113–117.

305. Find the height to which the Washington Monument must be built so that a body placed on top of it would have no weight. (Exercise 52, with solution.) Ann. Math., 2, 1885–86, pp. 23, 66–67.

306. Observations of the satellites of Saturn and of the companion of Sirius. Astron. Soc. Month. Not., 45, 1884–85, pp. 425–427.

307. Observations of Hyperion. [1881–85.] Astr. Nachr., 111, 1885, col. 295–302.

308. Observations of the partial solar eclipse, 1885, March 15–16. [By A. Hall, E. Frisby, and H. M. Paul.] Astr. Nachr., 111, 1885, col. 319–320; Sidereal Messenger, 4, 1885, p. 123; Washington Obs'ns, 1882, Appendix II, p. 8.

309. Note on the parallax of 40 o^2 Eridani. Astr. Nachr., 112, 1885, col. 303–304. Abstract in Amer. Journ. Sci., 30, 1885, p. 403.

310. Defining power of telescopes. Observatory, London, 8, 1885, p. 174.

311. Height of land in Connecticut. Science, 6, 1885, p. 4.

312. Reineke Fuchs in political economy. Science, 6, 1885, p. 563.

313. Instruments and work of astronomy. An address delivered at the opening of the Leander McCormick Observatory of the University of Virginia, April 13, 1885. Washington, 1885. 19 pp., 23½ cm. Reprinted in Sidereal Messenger, 4, 1885, pp. 97–110.

314. [Unfavorable weather for observations during the spring and summer of 1885.—Mass of Uranus. Quoted from a letter to the editor.] Sidereal Messenger, 4, 1885, p. 153.

315. Commensurability of motions. Sidereal Messenger, 4, 1885, pp. 200–202; Observatory, London, 8, 1885, pp. 327–328.

316. Observations with the 26-inch equatorial, 1881. [Observers: A. Hall, E. S. Holden, and E. Frisby. Professor Hall observed Enceladus, Titan, Hyperion, Iapetus, the satellites of Uranus, of Neptune, and of Mars, double stars, &c.]—Results of observations made with 26-inch equatorial, 1881. Washington Obs'ns, 1881, p. 97–114.

317. Orbits of Oberon and Titania, the outer satellites of Uranus. [Washington Observations for 1881,] (Appendix I.) Washington, 1885. 33 pp., 29½ cm. Review in Astron. Soc. Month Not., 46, 1885–86, pp. 234–235.

318. Orbit of the satellite of Neptune. [Washington Observations for 1881,] (Appendix II.) Washington, 1885. 27 pp., 29½ cm. Review in Astron. Soc. Month. Not., 46, 1885–86, p. 235.

319. Observations with the 26-inch equatorial, 1882. [Observers: A. Hall and E. Frisby. Professor Hall observed the satellite of Neptune, Oberon, Titania, Titan, Hyperion, Deimos, conjunctions of the satellites of Saturn, and double stars.] Results of observations with the 26-inch equatorial, 1882. Washington Obs'ns, 1882, pp. 93–113.

320. Orbit of Iapetus, the outer satellite of Saturn. (Washington Observations for 1882, Appendix I.) Washington, 1885. 82 pp., $29\frac{1}{2}$ cm. Review in Astron. Soc. Month. Not., 46, 1885–86, pp. 235–236.

321. American scientific societies (Annual address of the President.) Washington, Phil. Soc. Bull., 8, 1885, pp. XXXIII–XLVII; Smithson. Misc. Coll., 33, 1888, Art. 3, pp. XXXIII–XLVII.

322. [Remarks on Hamilton's geometric system.] Washington, Phil. Soc. Bull., 8, 1885, p. 53; Smithson. Misc. Coll., 33, 1888, Art. 3, p. 53.

323. [Remark on field time determinations.] Washington, Phil. Soc. Bull., 8, 1885, p. 58; Smithson. Misc. Coll., 33, 1888, Art. 3, p. 58.

324. Letter to Mrs. Smith [from the committee on the J. Lawrence Smith medal, dated July 27, 1885, accepting the trust in behalf of the Academy. Signed by Wolcott Gibbs and others, including A. Hall.] Washington, Proc. Nation. Acad., 1, 1863–94, pp. 263–264; Report . . . 1885, p. 12.

1886.

325. Nova Andromedæ. Amer. Journ. Sci., 31, 1886, pp. 299–303. Noticed in Nature, 33, 1885–86, p. 367.

326. Four points are taken at random on the surface of a sphere. What is the probability that all of the points do not lie in the same hemisphere? (Exercise 74, with solution.) Ann. Math., 2, 1885–86, pp. 72, 133.

327. Figure of the earth and the motion of the moon. Ann. Math., 2, 1885–86, pp. 111–112.

328. "Find the thinnest frustum that can be cut from a given right circular cone by a plane parallel to the base, subject to the condition that it may be laid on its slant surface on a horizontal plane without toppling over." (Exercise 84, solved.) Ann. Math., 2, 1885–86, p. 136.

329. If m be a positive integer, $\sin (m-1)\,\phi - x \sin m\,\phi + x^m \sin \phi$ will contain $1 - 2x \cos \phi + x^2$. (Exercise 106, with solution.) Ann. Math., 2, 1885–86, p. 144; 3, 1887, p. 62.

330. Observations . . . [Satellites of Saturn and of Mars, companion of Sirius] Astron. Soc. Month. Not., 46, 1885–86, pp. 453–455.

331. La latitude varie-t-elle? L'Astronomie, 5, 1886, pp. 370–375.

332. Observations of comets . . . [Observers: A. Hall, E. Frisby, and W. C. Winlock. Professor Hall observed Comet II, 1885.] Astr. Nachr., 113, 1885–86, col. 257–260, with some of the observations by Messrs. Frisby and Winlock omitted in Sidereal Messenger, 5, 1886, p. 19.

333. Nebulæ in the Pleiades. Astr. Nachr., 114, 1886, col. 167–168.

334. Observations . . . [Hyperiòn and Polyhymnia.] Astr. Nachr., 115, 1886, col. 75–78.

335. Comparison of the observations of the five inner satellites of Saturn, made at Toulouse in 1876 and 1877. Astr. Nachr., 115, 1886, col. 97–104. Noticed in Nature, 34, 1886, p. 490.

336. A cerca della nueva estrella de Orion. Cronica Científica, Barcelona, 9, 1886, pp. 80–81.

337. Proposed change in the astronomical day. Observatory, London, 9, 1886, p. 161.

338. Science and Lord Bacon. Science, 7, 1886, p. 143.

339. Reports of the National Academy of Sciences. ["Generally a report is not submitted to the Academy for discussion, and it must be understood to represent only the opinion of the committee who sign the report."] Science, 7, 1886, p. 286.

340. World time. Science, 7, 1886, p. 373.

341. Cremona's *Projective geometry.* Science, 8, 1886, p. 631.

342. Images of the stars. Sidereal Messenger, 5, 1886, pp. 97–100.

343. Six inner satellites of Saturn. (Washington Observations for 1883, Appendix I.) Washington, 1886. 74 pp., 28½ cm. Reviewed by A. Marth in Astron. Soc. Month. Not , 47, 1886–87, pp. 177–178; Nature, 35, 1886–87, pp. 257–258.

344. Observations for stellar parallax. (Washington Observations for 1883, Appendix II.) Washington, 1886. 67 pp., 29½ cm. Reviewed in Astron. Soc. Month. Not., 47, 1886–87, pp. 183–184; Nature, 35, 1886–87, p. 258.

345. Reports of the Home Secretary, 1886–1896. [Mostly oral and relating to the printing of the publications of which he was *ex officio* one of the editors.] Washington, Proc. Nation. Acad., 1, 1863–94, pp. 270, 284, 295, 314–315, 333, 346, 362, 379, 389–390; Report . . . 1886, p. 7; 1887, p. 7; 1888, p. 7; 1889, p. 7; 1890, p. 6; 1891, p. 6; 1892, pp. 11–12; 1893, p. 9; 1894, p. 7; 1895, p. 14; 1896, p. 7.

1887.

346. Special case of the Laplace coefficients $b_s^{(1)}$. Ann. Math., 3, 1887, pp. 1–11.

347. "Find the value of $\int Q dx$ where $Q = \cos(a_1 x + b_1)\cos(a_2 x + b_2) \ldots \cos(a_n x + b_n)$, $a_1, a_2, \ldots a_n$ and $b_1, b_2, \ldots b_n$ being constants." (Exercise 116, selected.) Ann. Math., 3, 1887, pp. 32, 118.

348. "Find an expression for the area of a quadrilateral inscribed in an ellipse in terms of the eccentric anomalies of its vertices and the axes of the curve." (Exercise 123, solved.) Ann. Math., 3, 1887, pp. 122–123.

349. If r and r' be radii vectores in a parabola, and if $2f$ the difference of the true anomalies, the area of the parabolic sector between the radii is $\frac{1}{3}\sqrt{(rr')}\sin f \,.\, [r + r' + \sqrt{(rr')}\cos f]$. (Exercise 152, with solution.) Ann. Math., 3, 1887, pp. 160, 188.

350. "Find the condition that the chords AB, CD in an ellipse should meet the transverse axis in points equidistant from the center, the points A, B, C, D being given by their eccentric anomalies α, β, γ, δ." (Exercise 146, solved.) Ann. Math., 3, 1887, p. 187.

351. Note on Mr. Stockwell's "*Analytical determination of the inequalities in the motion of the moon, arising from the oblateness of the earth.*" Astron. Journ., 7, 1886–88, p. 41.

352. Relative positions of 63 small stars in the Pleiades. Astron. Journ., 7, 1886–88, pp. 73–78.

353. Parallax of α Tauri. Astron. Journ., 7, 1886–88, pp. 89–91. Brief notices in Washington, Phil. Soc. Bull., 10, 1887, p. 91; Smithson. Misc. Coll., 33, 1888, Art. 4, p. 91. Results in Nature, 36, 1887, p. 138.

354. Observations of the companion of Sirius. Astron. Journ., 7, 1886–88, p. 99. Mean results in Nature, 36, 1887, p. 186.

355. Nomenclature of double stars. Astron. Journ., 7, 1886–88, p. 120.

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357. Note on the orbits of satellites. Brit. Assoc. Rep., 56, 1886, pp. 542–543.

358. Power of a voter. [With table showing the relative power in each state of the Union.] Science, 9, 1887, p. 364.

359. Applied optics. [Note in approval of R. S. Heath's book and calling attention to the omission of Biot's writings from the bibliography contained therein.] Science, 10, 1887, p. 108.

360. 'Act of God' and the railway company. [A query to Mr. Appleton Morgan.] Science, 10, 1887, p. 264.

361. Rejection of discordant observations. Sidereal Messenger, 6, 1887, pp. 297–301; Observatory, London, 10, 1887, pp. 414–417.

362. Observations with the 26-inch equatorial, 1883. [Observers: A. Hall, E. Frisby, and A. Hall, Jr. Professor Hall observed the satellite of Neptune, Oberon, Titania, Iapetus, Titan, Hyperion, Rhea, conjunctions of the satellites of Saturn, double stars.] Results of observations with the 26-inch equatorial, 1883. Washington Obs'ns, 1883, pp. 119–142.

363. [Remarks on the motion of Hyperion.] Washington, Phil. Soc. Bull., 10, 1887, p. 91; Smithson. Misc. Coll., 33, 1888, Art. 4, p. 91.

364. Euler's Theorem, generally called Lambert's. Abstract. Washington, Phil. Soc. Bull., 10, 1887, pp. 101–102; Smithson. Misc. Coll., 33, 1888, Art. 4, pp. 101–102.

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365. On the supposed canals on the surface of the planet Mars. [Title only.] Amer. Assoc. Proc., 37, 1888, p. 64.

366. P and Q are middle points of the opposite edges of a tetraëdron. A plane through PQ intersects two other opposite edges in M and N. Show that MN is bisected by PQ. (Exercise 207, with solution.) Ann. Math., 4, 1888, pp. 63, 135.

367. Motion of Hyperion. Astron. Journ., 7, 1886–88, pp. 164–165.

368. Occultations of stars by the moon during the lunar eclipse of 1888, January 28 . . . [Observed by A. Hall, E. Frisby, and H. M. Paul.] Astron. Journ., 7, 1886–88, p. 176.

369. Constant of aberration. Astron. Journ., 8, 1888–89, pp. 1–5, 9-13. Title only, in Washington, Proc. Nation. Acad., 1, 1863-94, p. 292; Report . . . 1887, p. 11.

370. [Observation of the satellite of Neptune, made November 19, 1883, with the 23-inch equatorial, Halsted Observatory, Princeton, N. J.] Astron. Journ., 8, 1888–89, p. 14.

371. Extension of the law of gravitation to stellar systems. Astron. Journ., 8, 1888–89, pp. 65–68. Abstract in Nature, 38, 1888, p. 398.

372. Satellite of Neptune. Astron. Journ., 8, 1888–89, p. 78.

373. Appearance of Mars, June, 1888. Astron. Journ., 8, 1888–89, p. 79.

374. Observations of Hyperion. [1886–88.] Astron. Journ., 8, 1888-89, pp. 95–96.

375. Observations on Mars. [Observations of the satellites, March–May, 1888.] Astron. Journ., 8, 1888–89, p. 98.

376. Problem of alignment. Astron. Journ., 8, 1888–89, pp. 143, 147.

377. Conspiracy of silence. [Comments on the Duke of Argyll's charge of a conspiracy among scientific men, by means of which new truths are ignored.] Science, 11, 1888, p. 37.

378. What is force? Washington, Phil. Soc. Bull., 11, 1888–91, pp. 583–587.

379. Problem-solving. Washington, Phil. Soc. Bull., 11, 1888-91, pp. 598-600.

380. On a method of deducing the right ascension and declination of an object observed to be at the intersection of the diagonals of a quadrilateral of the celestial sphere, from the right ascensions and declinations of the four vertices of the quadrilateral. [Title only.] Washington, Phil. Soc. Bull., 11, 1888–91, p. 601.

381. [Report of the Committee on the] Presentation of the first J. Lawrence Smith medal [to Prof. Hubert A. Newton in recognition of his eminent services in the investigation of the orbits of meteors. Signed by Wolcott Gibbs and others, including A. Hall.] Washington, Proc. Nation. Acad., 1, 1863–94, pp. 308–310; Report . . . 1888, pp. 14–16.

382. Note on the satellite of Neptune. [Title only.] Washington, Proc. Nation. Acad., 1, 1863–94, p. 312; Report . . . 1888, p. 20.

1889.

383. Note on symbols. Ann. Math., 5, 1889-90, p. 19.

384. "A homogeneous sphere rests on another such sphere of equal mass, which rests on a table. Everything being smooth and the system being slightly shaken, show that the spheres will separate when the upper one is turned through the angle $\cos^{-1}(\sqrt{3}-1)$." (Exercise 250, solved.) Ann. Math., 5, 1889–90, p. 31.

385. Show that the attraction of a finite mass on one of its points is finite. (Exercise 276, with solution.) Ann. Math., 5, 1889–91, pp. 68, 216.

386. White spot on the ring of Saturn. Astron. Journ., 9, 1889–90, p. 23.

387. Position of the Washington 26-inch refractor, 1876–1889. Astron. Journ., 9, 1889–90, p. 32.

388. Deduction of planetary masses from the motions of comets. Astron. Journ., 9, 1889–90, p. 47.

389. Note on the ring-nebula in Lyra. Astron. Journ., 9, 1889–90, p. 64.

390. Observations of 70 Ophiuchi . . . Astron. Journ., 9, 1889–90, p. 75.

391. Observations of the occultation of Jupiter by the moon, 1889, September 3 . . . [Observers: A. Hall, 26-inch equatorial, power 383; A. N. Skinner, 9.6-inch equatorial, power 132.] Astron. Journ., 9, 1889–90, p. 80.

392. Resisting medium in space. Sidereal Messenger, 8, 1889, pp. 433–442.

393. Observations with the 26-inch equatorial, 1884. [Satellite of Neptune, Oberon, Titania, Titan, Hyperion, Deimos, conjunctions of the satellites of Saturn, and double stars; by A. Hall.] Results of observations with the 26-inch equatorial, 1884. [To which is added, Results of observations of the companion of Sirius, 1880–84; observed by A. Hall, E. S. Holden, and E. Frisby.] Washington Obs'ns, 1884, pp. 181–216.

394. Saturn and its ring, 1875–1889. (Washington Observations, 1885, Appendix II.) Washington, 1889. 3 pl., 22 pp., 29 cm. Reviewed in Astron. Soc. Month. Not., 51, 1890–91, pp. 250–251; L'Astronomie, 10, 1891, pp. 137–138; Nature, 43, 1890–91, p. 65; Observatory, London, 14, 1891, p. 72.

395. On the problem: Given a chord drawn at random within a given circle, what is the probability that its length will be greater than the side of the inscribed equilateral triangle? [Title only.] Washington, Phil. Soc. Bull, 11, 1888–91, p. 605.

396. Saturn and its rings. [Title only.] Washington, Proc. Nation. Acad., 1, 1863–94, p. 331; Report . . . 1889, p. 12.

1890.

397. Observations of Comet *d*, 1889, Brooks . . . Astron. Journ., 9, 1889–90, pp. 135, 165–166.

398. Thickness of Saturn's ring. Astron. Journ., 10, 1890–91, pp. 41–42.

399. Latitude of the Naval Observatory. Astron. Journ., 10, 1890–91, pp. 57–58.

400. Observations of Eucharis (181). Astron. Journ., 10, 1890–91, pp. 62–63.

401. Observations of the satellites of Mars in 1890 . . . Astron. Journ., 10, 1890–91, pp. 74–75.

402. Observations of μ' Herculis. Astron. Journ., 10, 1890–91, p. 124.

403. "At the station A, the apparent angular elevation of a meteor B, whose distance from the earth's surface is one-nth of the earth's radius, is θ. Supposing the earth to be a perfect sphere, find the exact distance from A to B." (Mathematical Question 4193, solved.) Educational Times, 43, 1890, p. 340.

404. Astronomical photography. Knowledge, 13, 1889–90, p. 117.

405. Report of the Board of Trustees of the Watson Fund. [Recommending that a Watson medal be awarded to Dr. Arthur Auwers, of Berlin, for his contributions to stellar astronomy. Signed by Simon Newcomb, B. A. Gould, and Asaph Hall.] Washington, Proc. Nation. Acad., 1, 1863–94, pp. 345, 350–355. Report . . . 1890, pp. 13–14; 1891, pp. 8–11.

1891.

406. Find an approximate value for the perturbation of a comet by the sun, when the comet is very near a planet.—See Watson's *Astronomy*, p. 550. (Exercise 327, with solution.) Ann. Math., 6, 1891–92, pp. 76, 167.

407. Parallax of α Tauri. [Reply to a criticism by Mr. S. W. Burnham.] Astron. Journ., 11, 1891–92, p. 7.

408. Solar parallax and the mass of the earth. Astron. Journ., 11, 1891–92, pp. 20–21.

409. Observations of Hyperion. Astron. Journ., 11, 1891–92, p. 36.

410. Observations of β Delphini, τ Cygni, and ζ Ursæ Majoris. Astron. Journ., 11, 1891–92, p. 54.

411. Saturn. [Letter in regard to the difficulty experienced in making pictures of the planets.] Observatory, London, 14, 1891, pp. 201–202.

412. Spirit level. Sidereal Messenger, 10, 1891, pp. 187–188.

413. Observations with the 26-inch equatorial, 1885. [Observers: A. Hall, W. H. Allen, and A. Hall, Jr. Professor Hall observed Iapetus, Hyperion, conjunctions of the satellites of Saturn, and small stars in the Pleiades] Results of observations with the 26-inch equatorial, 1885. Washington Obs'ns, 1885, pp. 159–186.

414. Observations with the 26-inch equatorial, 1886. [Observers: A. Hall and W. H. Allen. Professor Hall observed Iapetus, Hyperion, Deimos, conjunctions of the satellites of Saturn, dimensions of Saturn's ring, double stars, and small stars in the Pleiades.] Results of observations with the 26-inch equatorial, 1886. Washington Obs'ns, 1886, pp. 107–141.

415. Note on ζ Cancri. ["Not published." Title only.] Washington, Phil. Soc. Bull., 11, 1888–91, p. 565.

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416. Orbit of Iapetus. Astron. Journ., 11, 1891–92, pp. 97–102.

417. Relative motion of 61 Cygni. Astron. Journ., 11, 1891–92, pp. 140–141.

418. Notes on double stars. Astron. Journ., 12, 1892–93, pp. 4–6, 33–36; 13, 1893–94, pp. 113–114, 119–121.

419. Occultation of Mars, 1892, July 11. Astron. Journ., 12, 1892–93, p. 55.

420. Observations of μ' Herculis. Astron. Journ., 12, 1892–93, p. 79.

421. Letter . . . to Senator Hale, of Maine, April 23, 1892. [On Mr. Morrill's amendment to the Naval appropriation bill, proposing a reorganization of the Naval Observatory.] 53d Cong., 1st sess., Senate Misc. Doc. No. 206, p. 2.

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Enceladus, Tethys, Dione, Rhea, dimensions of Saturn's rings, satellites of Mars, and double stars.] . . . Results of observations, 1888. Washington Obs'ns, 1888, pp. B 45–B 52, C 21–C 30.

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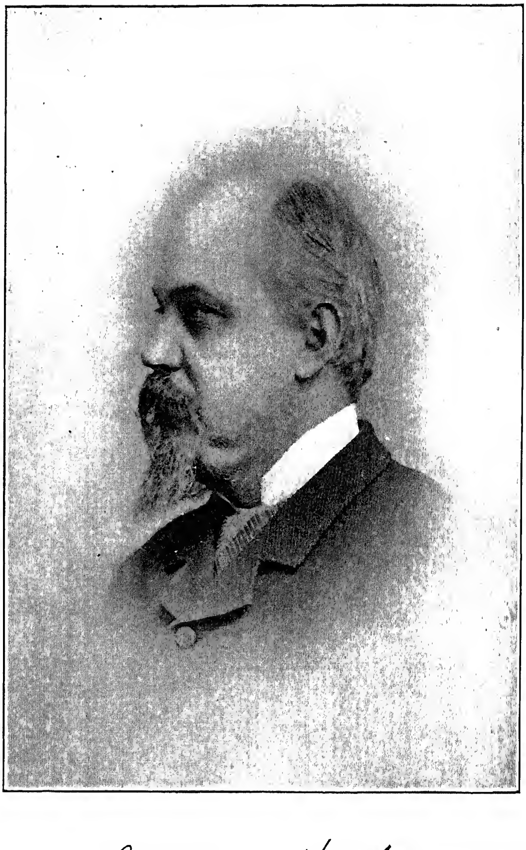

Alpheus Hyatt

BIOGRAPHICAL MEMOIR

OF

ALPHEUS HYATT.

1838–1902.

BY

WILLIAM KEITH BROOKS.

[READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL 23, 1908.]

BIOGRAPHICAL MEMOIR OF ALPHEUS HYATT.*

ALPHEUS HYATT was born in Washington, D. C., on the 5th of April, 1838, and he died in Cambridge, Massachusetts, on the 15th of January, 1902, in his sixty-fourth year. His death was sudden, taking place while he was on his way to a meeting of the Boston Society of Natural History, of which he had been for thirty-two years an officer.

While he was born in Washington, Baltimore was the home of his childhood. It was then and is still the residence of other members of the family. His father's home, an estate known as Wansbeck, was then outside the city, but it is now the Child's Nursery and Hospital of Baltimore, on the corner of Franklin and Shroeder streets.

When eight years old he was sent away to school, spending only his vacations at home. He soon entered the Maryland Military Academy, remaining there until, at the age of eighteen, he entered the class of 1860 at Yale. At the end of his first year he was called home to accompany his invalid mother abroad. While at Rome, on this journey, strong influence was brought to bear by his Roman Catholic mother and her spiritual advisers to induce him to devote himself to an ecclesiastical life; but his mind was fixed upon a scientific career, and at the end of the year abroad he entered the Lawrence Scientific School of Harvard University to study engineering. He soon fell under the influence of Agassiz, whose enthusiastic inspiration and illustrious example, together with the encouragement of the devoted young men whom he had drawn about him and the attraction of the museums of Cambridge and Boston, soon stimulated the zeal of Hyatt for pure science, and he abandoned the study of

* The preparation of this sketch of the life of Alpheus Hyatt has been a labor of love, but I regret that it has fallen to me, for I did not know I was to undertake it until the summer of 1907, and in the meantime, more than five years after his death, three biographies of Hyatt have been written and published by three members of the National Academy whose acquaintance with him was much older and closer than my own.

engineering to devote his life to zoölogy. Among his young companions and fellow-students under Agassiz were eight who became eminent as investigators and teachers of zoölogy and were in good time elected to the National Academy, one of them becoming its President. In 1860 they organized a zoölogical society, which met for reporting the progress of their work and discussing the researches they were carrying on and subjects of general interest to zoölogists. This society they named after the teacher, who attended the meetings and gave inspiring reminiscences of Humboldt, Cuvier, Dollinger, and other eminent men. Hyatt attended the meetings and took an active part in the discussion, every new conception calling forth a response from him and opening to him new avenues of thought. So eloquently did Agassiz set forth the embryological system of von Baer that it made a profound and permanent impression upon Hyatt. The physico-philosophical system of Oken and the high praise accorded to him by Agassiz also influenced Hyatt and led him to consider his work from points of view induced by these great men. We are told that he also learned by heart Agassiz's Essay on Classification.

One of his fellow-students saw that, as a young man, Hyatt was contemplative, taking life seriously. Despite this sober attitude, he was brimming over with good nature, laughing heartily at a joke, even when he was the victim of it. He was devoted to his work and was among the few who found more delight in keeping steadily at work at their studies when the college was deserted in summer than in taking a vacation. We are told that his concentration upon his work gave him the appearance of an absent-minded man. His attention was indeed absent from his immediate surroundings, but it was by no means wandering in other directions. So absorbed would he become at times that he appeared to be in a dream, from which he could be aroused only by a slap or a shout.

This pleasant student life came to an end, for the time, when he was graduated from the Scientific School, in 1862; for he believed it his duty to give to his country, which was then at war, the benefit of his military training. He did not hesitate to act upon his conviction, although he knew he should thus estrange himself from those who were nearest and dearest to

him, for his relatives in Maryland sympathized with the South. He gave efficient aid in raising and instructing a company in Cambridge, and he was commissioned a lieutenant, although he was soon promoted to the rank of captain in the 47th Massachusetts regiment. He enlisted a second time at the end of his first term of service, and he was mustered out at the end of the war, in 1865. It was not until nearly thirty years after that his relatives became reconciled to their Union veteran; but we who knew him as a man of science will regard as some compensation the military bearing that contributed to the impressive dignity of his presence.

He returned to Cambridge in 1865 to renew his researches under the guidance of Agassiz, devoting himself to the study of the fossil cephalopods. The same year he was made honorary curator of the Museum of Comparative Zoölogy and put in charge of the fossil cephalopods. He continued to hold this position to the end of his life. During the thirty-nine years that remained to him the study of these fossils held the foremost place in his thoughts. His first important memoir, which was published in 1866, gives some of the results of six years of interest in them. Another memoir on the same subject followed in the next year, and others in succeeding years, the last being published in 1901, only a few months before his death.

In 1867 he married Ardella Beeby, of New York; and she, with three children, survives him.

The same year he moved to Salem, Massachusetts, and, with three friends who had been his fellow-students at Cambridge, continued scientific researches at the Essex Institute, of which he and his three friends were made curators, and at the Peabody Academy, which they coöperated in organizing in 1869. They also founded and were the first editors of and contributors to the *American Naturalist*, the first successful and permanent journal of general zoölogy, as it is still the leading one. The three friends who were so closely associated with Hyatt in these early undertakings remained his life-long friends and collaborators. They are our colleagues, Prof. E. S. Morse and F. W. Putnam, and our late colleague, A. S. Packard.

While at Salem in 1869, Hyatt was elected a fellow of the American Academy of Arts and Sciences, of which he was one of the vice-presidents at the time of his death.

He remained at Salem until 1870, when, on May 4, he was elected custodian of the Boston Society of Natural History. By yearly choice he remained the scientific head of the society until his death, near the end of his thirty-second year of service. An officer of the society who was associated with him for many years speaks of his service to it in the following words:

"For the head of a museum of natural history, Professor Hyatt had many and marked qualifications; his knowledge of zoölogy, of paleozoölogy, and of geology was extensive; he was skillful in manipulation, suggestive in council, enthusiastic, and approachable.

"His plan, that a natural history museum should be arranged so that a visitor on entering should pass from the simpler groups to those more specialized, and that the specimens in each case should be similarly classified, though opposed as impracticable, is both sound and feasible. Somewhat disposed in late years to a too great use of diagrams and models in place of the actual material, his recognition of the value of these, of descriptive labels, and of a personal guide was early, important, and helpful.

"It is true that the full realization of much of his best museum work and thought is left for appreciative successors, as Professor Hyatt was too apt to be content with initiative, the results of which he clearly apprehended, and did not always give attention to the actual carrying out of details that in many cases require continuous interest through successive years."

In his first year of service at the Natural History Society he was appointed Professor of Zoölogy and Paleontology at the Institute of Technology—a position which he filled for eighteen years. In the same year he organized the Teachers' School of Science, which during the thirty years that he continued to direct the work gave practical instruction in science to more than twelve hundred teachers, who diffused and are still diffusing among the young the inspiration of Hyatt's example and that of Agassiz, his own teacher. In good time and after long struggles against opposition and lack of means the school became permanently established upon a sound educational basis, with adequate financial support and with an efficient staff of assistants and colleagues, who were able and willing to conduct exercises in the laboratory and excursions in the field with big

classes of critical teachers. While the inception of this undertaking was a sign of the times and part of an educational reform that was in progress in many lands, its influence for good and its long career of usefulness should place the name of Hyatt with those of Agassiz and Huxley as teachers of the aims and methods of science and their importance in general elementary education. In 1882 the school was opened to all teachers in the State. As the general audience gradually decreased, it became clear that it had accomplished its original purpose, and it was reorganized into specific courses of study extending over four years, with regular examinations and diplomas, thus giving to busy teachers opportunities for a scientific education equal to that which is afforded by the ordinary colleges and scientific schools. Hyatt's spirit and example have pervaded the whole history of the school, which has had a notable and wholesome influence upon elementary education.

Hyatt also organized, as an adjunct to the school, and took personal charge of, the seaside laboratory at Annisquam, Massachusetts, which was established under the auspices of the Woman's Educational Association of Boston. When this example led to the establishment of an educational laboratory at Woods Holl, he was elected the first president of its board of trustees.

The year 1875, in which he was elected to the National Academy of Sciences, he spent abroad for the purpose of studying in the museums of Europe the collections of shells of Planorbis from the quarries at Steinheim, near Stuttgart, as he wished to learn how far these fresh-water mollusks, which are confined to a limited area and restricted to a short period of time, confirm the conclusions as to the origin of species which he had reached through the study of the Jurassic ammonites, which cover an immeasurable period of time. Not content with studying the collections of these shells that he found in museums at home and abroad, he visited Steinheim and spent five weeks in excavating the quarries himself, making new and extensive collections of the shells, which supplied the material for a memoir on the subject, which he published in 1880.

In 1877 he was made Professor of Biology in the College of Liberal Arts in Boston University. He organized the courses of

instruction, secured able assistants, and continued to supervise and direct the work until his death, after twenty-five years of service.

In 1883 he took a prominent part in organizing the American Society of Naturalists. He was chosen its first president, and was afterwards made an honorary member in recognition of his services.

In 1888 he was offered the position of United States Commissioner of Fish and Fisheries, but he declined it.

In 1889 and years following he was in charge, as paleontologist of the United States Geological Survey, of the Lower Mesozoic of Texas and California. He also carried on from time to time researches in paleontology in Labrador, Newfoundland, Canada, New England, and New York, and zoölogical explorations of the waters of the coast from Labrador to Connecticut.

In 1895 he was elected to the American Philosophical Society, and in 1897 he was made a corresponding member of the Geological Society of London.

In 1898 Brown University conferred upon him the degree of Doctor of Laws.

The last years of Hyatt's life were almost completely devoted to the study of the relation between the geographical distribution of the Achatinellidæ of the Hawaiian Islands and the endless variety of color-patterns presented by these mollusks, as he believed that this study would throw important light upon the general problem of the origin of species. He obtained great numbers of the shells of these mollusks, and, making a plaster model of Oahu, with each mountain range and valley in relief, and representing the probable lines of migration by colored threads, he devoted several years to the task of tracing out the origin of new color-patterns. At the time of his death, in January, 1902, he had perfected his plans for a visit to the islands in the following March for the purpose of studying the subject in the field.

The titles of some of his more important memoirs are these: Observations on Polyzoa (1866–68); On the Parallelism between the Different Stages of the Life of the Individual and those of the Entire Group of the Molluscous Order Tetribranchiata (1867); Fossil Cephalopods of the Museum of Comparative

Zoölogy; Embryology (1867); Revision of the North American Porifera (1875-77); The Genesis of the Tertiary Species of Planorbis at Steinheim (1880); Genera of Fossil Cephalopods (1883–84); Larval Theory of the Origin of Cellular Tissue (1884–85); Genesis of the Arietidæ (1889); Bioplastology and the Related Branches of Biological Research (1893); Phylogeny of an Acquired Character (1894); Cephalopoda (1900).

Most of the memoirs are beautifully illustrated by the author, whose artistic and accurate pencil adds greatly to their value.

Hyatt's researches on the Polyzoa of fresh water, on the sponges of North America, and upon the Mollusca of fresh water and of the land are worthy of notice, but his most important works are those that treat of the fossil cephalopods. These organisms held the foremost place in his mind throughout the whole period of his scientific activity, and they afforded the material for most of his published memoirs. These memoirs won for him distinction among zoölogists and paleontologists, and upon them his fame must rest. It is estimated that there are some twenty-five hundred species of Nautiloids and some five thousand species of Ammonoids, and Hyatt became familiar with most of those that are contained in the museums of Europe and North America. He discarded much of the established classification and established many new genera, which were more accurately defined than had been customary. This reformation excited opposition, but he lived to see it prevail. The brilliant work of a younger generation of paleontologists who acknowledge him as one of their great masters and leaders is the best proof of his success.

If this catalogue of his works conveys the impression that they lack unity, and that they were not inspired by any broad central principle, I regret this exceedingly. Few naturalists who have carried on researches in many fields for many years have been actuated, as Hyatt was from beginning to end, by a single motive, which has inspired and directed all they have undertaken and has never been absent from their minds for an instant of their working hours. Hyatt was accustomed to speak of his own guiding motive as the "old-age theory." No account of his life is complete without a statement regarding this doctrine, which exercised a great influence over all his work; yet I must admit that I do not understand it.

A life-long friend, who was his fellow-student in the early days at Cambridge, gives this account of its inception: "I have always believed," he says, "that Hyatt's studies of the features attending old age, and ultimately his theory of acceleration and retardation, received its first impulse from a graphic lecture given by Agassiz on the ammonites of the Jura.

"In the upper beds of the Jura, as is well known, the ammonites assume bizarre forms, the whorls becoming uncoiled, free, and variously turned. In this lecture Agassiz, by way of metaphor, compared the appearance of these ammonites to the contortions and death-struggles preceding the extinction of the group. In referring to these curious forms, 'It is,' said he, 'as if the contortions of death were an idea on which the forms of life were built.'"

As is well known, Agassiz regarded a species as an idea in the creative mind, independent of and superior to its manifestation in material beings. The conception of the mutability of species was demanding the consideration of thoughtful men at this time, and the publication of Darwin's Origin of Species was almost simultaneous with the publication of Agassiz's Essay on Classification, which we are told that Hyatt learned by heart.

Hyatt was influenced, as were his companions, by the new view, and he seems to have sought a compromise in the conception that, while species change, a long series of species has a life cycle like that of an individual organism, passing from the infancy of its first appearance through childhood and adolescence to perfect manhood, to lapse into senility, ending in death or the end of the long series of species, which is no longer represented by fossils in later formations.

Hyatt believed that we have in the old-age theory an explanation of the way in which species arise and pass away—an account of the origin of species.

In the case of the ammonites the well-known facts are these: The earliest forms are unornamented and their septa are simple. They are followed in geological succession by forms that are ornamented with spines and tubercles, with their septa folded and frilled in a way that gives to us a keen sense of their elegance and grace. In still more recent forms all these graceful and elegant features reach their highest perfection. In still

later forms the spines and tubercles and ornaments gradually disappear, the frills and folds in the septa become reduced, and there is a return to the primitive simplicity of the group, together with loss of symmetry and the appearance of abnormality and distortion.

Hyatt interpreted this remarkable history as a life cycle, consisting of infancy, childhood, manhood, and old age, ending in death or the extermination of the group of ammonites. It was in no figurative way that Hyatt illustrated the history of the ammonites by the life of an individual organism. He regarded it as an illustration of the great law according to which new species of living beings come into existence. As modern views of organic evolution prevailed, Hyatt made many modifications of the old-age theory in order to bring it into harmony with the progress of knowledge. I have studied his more recent writings upon the subject with all the diligence that my great respect and admiration for him demanded, I have listened attentively when he has discussed his views in public, and I have had many private talks with him about them, but I do not understand them.

As a man, Hyatt was dignified, courteous, kindly, and approachable, making no distinction of persons. He retained to the end the love and admiration of the companions of his student days. His patience and persistency in overcoming opposition and in scientific research were as great as they well could be. He met adverse criticism with unruffled calmness and good nature. Incivility and discourtesy he met with astonishment, but without rancor. He gave just cause of offense to no one. Naturally gentle, he yet stood firmly for justice and right, in peace as well as in war, and he was always ready to do battle in a righteous cause when friendship called for action.

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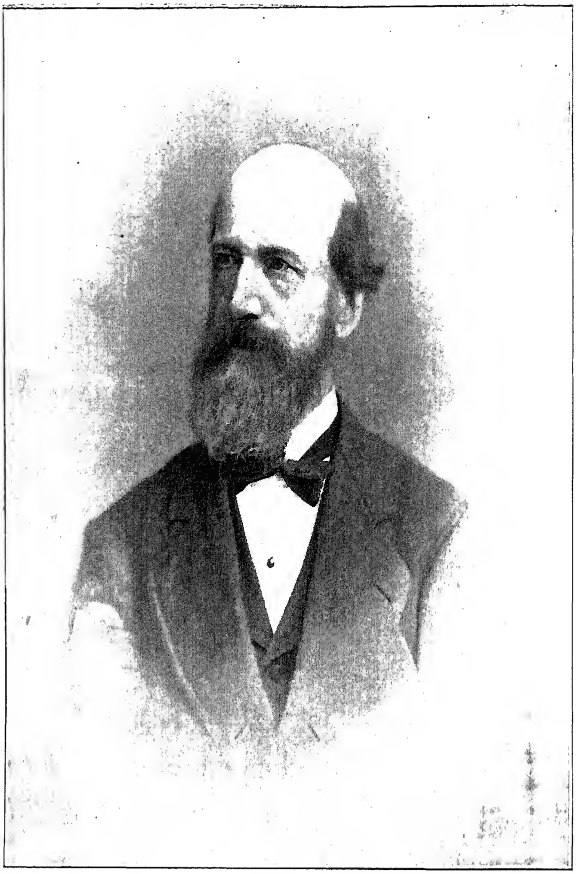

Joseph Lovering.

NATIONAL ACADEMY OF SCIENCES
BIOGRAPHICAL MEMOIRS
PART OF VOLUME VI

BIOGRAPHICAL MEMOIR

OF

JOSEPH LOVERING

1813-1892

EDITED BY

B. OSGOOD PEIRCE

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
NOVEMBER 18, 1908

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
March, 1909

NATIONAL ACADEMY OF SCIENCES.

Of the biographical memoirs which are to be included in Volume VI, the following have already been issued:

WASHINGTON, D. C.
JUDD & DETWEILER, INC., PRINTERS.
1909.

BIOGRAPHICAL MEMOIR OF JOSEPH LOVERING.*

PROF. JOSEPH LOVERING was born at Charlestown, Massachusetts, December 25, 1813, and received his early education in the public schools of that place. His father, a subordinate town officer, was a member of the Unitarian church then under the pastoral care of the Rev. James Walker, who afterward became a professor in Harvard College, and eventually the President of Harvard University. At school young Lovering proved himself an apt and diligent scholar, and this brought him under the notice of Dr. Walker, who employed him as reader, and soon saw in the lad such unusual promise that he urged him to fit himself to enter college, and not only aided the boy with personal instruction, but advanced the money necessary to pay his college expenses. In 1830 Lovering entered the sophomore class at Harvard, and was graduated in 1833. In his academic course he soon distinguished himself. Prof. Andrew Preston Peabody, who was his instructor in astronomy, said that Lovering was one of the three or four students on whom he relied to do credit to the class in the public oral examination held at the end of the term. With a few of his fellows, Lovering studied Hebrew also with Dr. Peabody, and made a deep impression on his teacher, who afterward spoke with admiration of his diligence, promptness, and accuracy. Lovering stood fourth in a class which furnished six professors to Harvard and four to other institutions. At commencement he delivered the Latin salutatory oration, and three years later, when, according to the fashion of the time, the members of his class were entitled to receive the Master's degree, he gave the valedictory oration.

During the first year after graduation he taught a small private school in Charlestown, but in the autumn of 1834 he entered the Divinity School at Cambridge, with the intention of preparing himself for the ministry. He remained in the school

*Compiled from the addresses made by Prof. J. P. Cooke, President Eliot, Rev. Dr. A. P. Peabody, and others at the meeting of the American Academy of Arts and Sciences, Boston, held in commemoration of the life and services of Professor Lovering.

for two years. During a part of 1834-5 he assisted Prof. Benjamin Peirce in the instruction of the college classes in mathematics, and in 1835-6 added to this work the duties of proctor, and much of the time conducted both the morning and the evening services in the College Chapel, in place of the regularly appointed clergyman. In 1836 Lovering seems to have given up definitely his purpose of becoming a preacher, and in the autumn of that year he became tutor in mathematics and lecturer in natural philosophy in Harvard College, taking the work of Prof. John Farrar, whose failing health had led him to resign. In 1838 he finally succeeded Professor Farrar as Hollis Professor of Mathematics and Natural Philosophy.

The active duties of this office Professor Lovering discharged without assistance for the unprecedented term of fifty years, and on resigning in 1888 he was appointed by the Corporation of the University "Hollis Professor Emeritus," so that he continued his connection with Harvard College until his death, in 1892, put an end to a service of fifty-eight years.

Professor Farrar had a very high reputation for eloquence, and it must have been a severe ordeal to the young man to attempt to fill the place of such a brilliant lecturer as Farrar had been. The event showed, however, that, although he did his work in a very different way, Lovering's instruction was no less effective than that of his celebrated and popular predecessor. From the very first his success was unmistakable, and, in the estimation of the New England college world, he soon came to hold a prominent place in the rank of lecturers on physics and astronomy.

At the beginning of Lovering's career as professor the Lyceum was still an educational institution, and much of his reputation was won on the public platform. At different times, beginning in 1840, he delivered nine courses of twelve lectures each before the Lowell Institute, and these were extremely popular. He had great clearness of thought and singular definiteness and felicity of expression. He was apt in illustration, and a quiet humor often enlivened what would have been otherwise a dry demonstration. He gave most careful attention to the mechanical preparation of his lectures, and his experiments rarely failed of success. Besides his regular college lectures, during term time

always one and usually two a week for a long period of years, and the lectures at the Lowell Institute above referred to, Professor Lovering gave shorter courses at the Smithsonian Institution in Washington, the Peabody Institute of Baltimore, and the Charitable Mechanics' Institution of Boston, and one or more lectures in many towns and cities of New England.

Prof. Josiah Parsons Cooke, who was himself one of the very best popular lecturers on science of the last generation, said after Professor Lovering's death:

"He was one of the best lecturers I have ever known, and I have known the greatest masters of my time. He may not have had the imagination of Faraday or the grace of Dumas, but his lectures were instructive in the highest degree. The chief sources of his power are not far to seek. In the first place, he had the great art of bringing his reasoning and his illustrations to the intellectual level of his hearers, without belittling his subject. He was a popular lecturer in the very best sense. He did not commit the common error of seeking to gain attention through trivialities, or of attempting to appear learned by using technical terms; but he sought to raise his audience from their lower plane to his level, and he succeeded to a wonderful extent. Again, he had remarkable clearness of statement, and he gained this in the only way it can be gained, by seeking definiteness of conception. He did not trust to the inspiration of the moment to make a difficulty, however familiar to him, intelligible to others; but he laboriously studied every subject he taught until he had a firm grasp of all the concepts, and then the stream was clear because the spring was clear. Lastly, Mr. Lovering had, to a greater degree than I have ever known, the power of looking at physical problems from different sides, and seeing them in all their aspects. This gave him great fertility in illustration, and often enabled him to present a subject from a point of view wholly unexpected even by adepts in the science.

"The wonderful clearness and elegance of exposition so conspicuous in Professor Lovering's lectures appeared also in his monographs and popular essays on scientific subjects. These are very numerous, and are models of scientific style.

"Besides their intrinsic value as the literary work of a very successful teacher, they are valuable material for the history of science. Professor Lovering's long career covers a period of wonderful development in all departments of physics, not simply in the discovery of new facts, but also in the change of aspect under which the old facts are regarded. He was a broad scholar, not only familiar with the past history of every branch of his subject, but also accustomed to look at facts from all sides."

As might have been expected from the character and the direction of his scientific work, Professor Lovering had marked executive ability, and, during the long period when he was Regent of Harvard College, then the second executive officer, he was in the highest degree methodical, accurate, and just. When the Jefferson Physical Laboratory was opened in 1884, Professor Lovering carried to it the very large and valuable collection of lecture apparatus which he had gradually accumulated during his long period of service as Hollis Professor. He took great pleasure and a just pride in this. When he entered upon his office there was already in the possession of his department a considerable number of philosophical instruments, some of which had a real historical interest, but they did not meet the requirements of a more modern science. Only a small annual appropriation could be obtained for the expenses of his lectures; but by carefully husbanding the resources, and doing all the mechanical work with his own hands, he was able from time to time not only to purchase the indispensable articles, but also to procure many novelties as they appeared. He judiciously used his large knowledge and judgment in the original selection, and by constant watchfulness prevented the apparatus from deteriorating, and thus during his long term of service he brought together one of the most complete cabinets of physical apparatus in this country. Nothing delighted him more than some new mode of illustrating a recondite principle in a striking way, and every year, at the meeting of the old Scientific Club of Cambridge, he would delight his associates also by bringing forward and explaining some such piece of apparatus, and he rose to the highest point of enthusiasm when he made it to appear that the paradoxes of science were no paradoxes at all, but the necessary unfoldings of fundamental laws.

In speaking of Professor Lovering's services to Harvard College, President Eliot once said:

"Professor Lovering's life seems to me to be better characterized by the word fidelity than by any other. He was just as faithful in the least things as in the greatest. Whatever work he undertook, he did thoroughly and steadily, although it might be uninteresting, mechanical, or really unsuitable for one of his station and powers.

"For twelve years, from 1857 to 1869, he was Regent of the college. That officer kept the records of absences and of the marks received by the students at their recitations. With his own hand Professor Lovering entered the absences and the marks in the record books, kept watch on the absences of every student in college, considered excuses, and reported delinquents to the faculty week by week. The Regent exercised discretion, and needed good judgment; but far the greater part of his time was devoted to accurate, patient clerical work. He was in his office three days of the week for two hours each day, and his compensation was five hundred dollars a year. I mention these details because they perfectly illustrate a quality in Professor Lovering which the men of a younger generation may well imitate—a capacity for assiduous routine labor. Every great scholarly achievement is accomplished by just such faithful industry. An inspiration is a momentary flash; a high purpose has an instant of formation; but inspiration and purpose have to be wrought out through years of unremitting labor.

"I have always admired in Professor Lovering the mixture of conservatism with openness of mind. His natural conservatism was modified by a true scientific candor. Change for its own sake he never desired; but he could be convinced by experience that a given change was an improvement. He held to the opinions and practices which he had adopted before he was forty years old; but his mind was also open to new projects. When the rapid expansion of Harvard University began in 1866, just after the close of the Civil War, Professor Lovering was already fifty-three years old and had been thirty years in the college service. When I was elected President he was fifty-six—a time of life at which many men become impatient of changes which seriously affect their own habits of work. Yet Professor Lovering welcomed the project of moving the entire physical establishment from its narrow quarters in University Hall to larger rooms in Harvard Hall. He personally arranged the lower floor of Harvard Hall to receive the Department of Physics and was highly content with the new accommodations of the department when the transfer was completed in 1870. But the department grew apace and the great gift of Mr. T. Jefferson Coolidge for the construction of a new physical laboratory made it possible to provide the department with larger quarters still and opened the way to a great increase both of the teaching and of the investigation which it carried on. At the age of seventy-one Professor Lovering entered heartily into this large undertaking, brought to it a flexible and fertile mind, moved again from Harvard Hall to the Jefferson Physical Laboratory, and was glad to be appointed the first director of that ample establishment."

Besides his uninterrupted work for the college, Professor Lovering discharged other executive duties in which he exhibited his usual faithfulness and good judgment. From 1854 to 1873 he was the Permanent Secretary of the American Association for the Advancement of Science—an office which requires an unusual amount of executive skill, besides tact and affability. On the Permanent Secretary devolve the arrangements for the annual meeting, the collection and disbursement of the funds, and the publication of the yearly volume of Proceedings. It is all important that he should commend the Association to the successive communities where it meets, and commend himself to the local committees. All this service Professor Lovering rendered with great success, and carried the society through the disintegrating period of the Civil War, when its continued life seemed impossible, and so skillfully managed its finances as not only to print a volume of Proceedings every year, but also to leave in the treasury at the end of his term of office a valuable stock of publications and a goodly cash balance. On resigning this office, Mr. Lovering was elected President of the Association, and served as such at the Portland meeting of 1873. Both his reception and his retiring addresses were admirable in thought as well as in spirit, and are excellent examples of the best use of idealism in science.

In the first of these he said: "It is impossible for the man of science to serve two masters, the Kingdom of Nature and Mammon. It is a dangerous thing for him to be thinking of the utility of his discoveries, or of the pecuniary profit which may be made out of them." And in the second he adds: "Science is not destructive, but progressive; while its theories change, the facts remain. Its generalizations are widening and deepening from age to age. We may extend to all the theories of physical science the remark of Grote which Challis quotes in favor of his own: 'Its fruitfulness is its correctibility.' Instead of being disheartened by difficulties, the true man of science will congratulate himself, in the words of Vauvenargues, that he lives in a world fertile in obstacles. Immortality would be no boon if there were not something left to discover, as well as to love."

Professor Lovering was also for some years one of the trustees of the Tyndall Fund for the endowment of research in physics,

and during the last few years of his life he was one of the trustees of the Peabody Museum of American Archæology and Ethnology.

He was elected a fellow of the American Academy of Arts and Sciences at Boston in 1839, and he served this society in various subordinate positions for thirty-three years, and as President during the last twelve years of his life. He became a member of the National Academy of Sciences in 1873, and was also a member of the American Philosophical Society of Philadelphia, of the California Academy of Sciences, and of the Buffalo Historical Society. In 1879 he received from his Alma Mater the degree of Doctor of Laws.

Professor Lovering was not a writer of books, but he was an editor of very large experience. He was co-editor with Prof. Benjamin Peirce of the "Cambridge Miscellany of Mathematics, Physics, and Astronomy," published at Cambridge in 1842 and 1843, and devoted to pure and applied mathematics. He edited fifteen volumes of the Proceedings of the American Association for the Advancement of Science, also six volumes of the Memoirs and three volumes of the Proceedings of this Academy, and earlier, in 1842, a new edition of Farrar's Electricity and Magnetism. In 1873, as has been said, he was the President for the year of the American Association, and in his reception address at Portland he said: "Few of us can aspire to the honor of being discoverers of the laws of nature in the highest sense of that phrase. But no one, however humble his capacities, or however limited his opportunities, who labors for science, will fail to advance it." This well expresses the attitude of Lovering toward his profession. He was not a born investigator, but one whose path in life was determined by force of circumstances, rather than by natural predilections. He was primarily a scholar, and the great service which he rendered to science was that of a scholar and a teacher, and not that of an experimenter.

But although Professor Lovering seems to have had little inclination to undertake original experimental investigation in physics, he did a very large amount of work in observing and correlating facts. He was associated with the late Prof. William C. Bond in the management of the primitive astronomical observatory first located at Cambridge in the dwelling-house

still remaining on the corner of Quincy and Harvard streets, and there took part in that concerted onset on the problem of the earth's magnetism instituted by Humboldt and Gauss, and continued throughout the British Empire for several years under the direction of the Royal Society of London. An appeal was made to various academies and men of science in this country to co-operate in the work, and the appeal was responded to by the Magnetic Observatory at Philadelphia under the care of the late Professor Bache, and by the American Academy of Arts and Sciences in Boston, which supplied the Cambridge Observatory with the requisite instruments. The plan of the Royal Society involved, besides frequent regular daily observations, an almost continuous watch on the magnetic needle during one day of each month. On these days, called term days, observations were made every five minutes on three different instruments, day and night. The chief burden of all this work fell on Professor Lovering, although he was greatly assisted, not only in the observations themselves, but also in their reduction and in the mathematical discussion of the results, by Professors Bond and Peirce and a few competent undergraduates. Of these last, Thomas Hill, afterward President of Harvard College, and Benjamin A. Gould, the distinguished astronomer, deserve special mention.

Professor Lovering's experience in this famous magnetic campaign must have familiarized him with the magnetic disturbances accompanying the auroral discharge, and thus led him to discuss the mooted question of the periodicity of the aurora. His study of this problem was the most considerable work of his life. It involved the collating and discussing of an immense number of more or less indefinite observations, and the mere presentation of the result of his laborious investigation occupies 350 quarto pages in the Memoirs of the American Academy of Arts and Sciences, new series, vol. x, part I. Professor Lovering clearly defined the secular periods of the aurora, and also showed that no apparent connection could be traced between the secular periodicity of the aurora and the secular changes of the earth's magnetism, the periods of sun-spots, fire-balls, or earthquakes, or any other secular changes with which the aurora had been associated by various physicists. As he writes in this memoir, "A lesson of caution against hasty conclusions on sub-

jects of such complexity may be drawn from the fact that whereas Boné favored the conclusion that the aurora goes hand in hand with the earthquake, and whereas Wolf had decided, though from data afterward acknowledged to be insufficient, that years rich in sun-spots corresponded to years rich in earthquakes, Kluge, from a more searching examination and the use of larger materials, finds a periodicity for earthquakes as long as that which governs the sun-spots and magnetic disturbances, but with maxima and minima reversed." We quote this as an indication of our colleague's judgment and caution in the discussion of observations, and although the investigation did not lead to the discovery of unsuspected relations, yet the negative results reached were of the greatest importance, and the memoir just referred to may be quoted as an example of great thoroughness in the collection of materials, and of remarkable freedom from bias in the discussion of results.

Between 1867 and 1876 Professor Lovering was connected with the United States Coast Survey, and had charge of the computations for determining differences of longitude in the United States, and across the Atlantic Ocean, by means of the land and cable lines of telegraph. The most important and interesting portion of the work which he did in this connection is discussed in a paper "On the Determination of Transatlantic Longitudes by means of the Telegraphic Cables," published in the Memoirs of the American Academy of Arts and Sciences, new series, vol. IX, 1867, Pt. 2, pp. 437-477.

Professor Lovering was pre-eminently a social man, and any notice of him would be incomplete that did not allude to this genial phase of his character. He was one of the few men who could hold his opinions and maintain his position without personal animosity or unfriendly feeling, could favor without partizanship, could oppose without bitterness. He never would quarrel, and, as he once said, it takes two to make a quarrel and the other man only counts one. Besides a frank cordiality and kindliness of greeting which made him very accessible, he had a fund of dry humor, which not only enlivened intercourse, but often gave force to an argument. Not unfrequently in meetings of the college faculty he would turn a stupid debate, and exhibit a question in its real absurdity, by a witty remark. There was

also a straightforwardness, integrity, and truthfulness about his intercourse which inspired confidence and warmly attached him to his friends. He was perfectly just and singularly free from bias, and in any question involving rectitude or faithfulness you could always count on him. He was faithful to every duty, and conscientiously discharged every obligation. He rarely, if ever, missed an appointment, and whatever he undertook, however unimportant, he did with all his might.

Besides attending and keeping up the spirit of the Cambridge Scientific Club, of which he was one of the original members, he was uniformly present at the meetings of the Thursday Evening Club in Boston, and often contributed to its Proceedings. He very greatly enjoyed these meetings, and his communications were always esteemed by the members. He had the happy faculty of popularizing a subject without degrading it. He could present a problem so that his audience could follow as far as he led, and understand why he did not attempt to lead them further. His discourse was always free from trivialities or redundances, and his hearers could appreciate the grandeur of the mountain all the better because they had not made a fruitless attempt to climb it.

It was a very fitting tribute to Professor Lovering's warm social nature that at the close of his active duties, in 1888, a banquet should be held in honor of his fifty years' service. It was the spontaneous offering of classmates, associates, pupils, and friends, and it afforded him the highest satisfaction.

Professor Lovering was married in 1844 to Sarah Gray Hawes, of Boston, and at his death his wife, with two sons and two daughters, survived him. After retiring from active work, he passed four serene and happy years. On several occasions he said to a colleague: "You don't know what a pleasure it is to be relieved from stated duties, and to have full command of your time. I have plenty to do, and never have an idle moment." Through great prudence and thrift he had laid aside a sufficient competency to relieve him from all pecuniary anxieties, and his friends had hoped that he might long pass the full term of four-score years. His wonderful vitality and singular immunity from disease encouraged this hope; but it was not to be. A severe cold, followed by influenza, weakened the heart, and the end

came in the early morning of January 18, 1892. He died peacefully and without pain.

The following catalogue of Professor Lovering's publications has been prepared in the office of the Home Secretary of the National Academy of Sciences. It is based on a list of titles given in the College Class-book entitled "Memorials of the Class of 1833 of Harvard College, prepared for the Fiftieth Anniversary of their Graduation by the Class Secretary, Waldo Higginson":

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1841-42. Mechanics.
1842-43. Astronomy.
1843-44. Optics.
1845-46. Astronomy.
1853-54. Electricity and Magnetism.
1859-60. Astronomy.
1865-66. Light and Sound.
1879-80. Connection of the Physical Sciences.

Yours truly
D McGall

NATIONAL ACADEMY OF SCIENCES
BIOGRAPHICAL MEMOIRS
PART OF VOLUME VI

BIOGRAPHICAL MEMOIR

OF

WILLIAM MORE GABB

1839-1878

BY

WILLIAM H. DALL

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
NOVEMBER 18, 1908

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
March, 1909

NATIONAL ACADEMY OF SCIENCES.

Of the biographical memoirs which are to be included in Volume VI, the following have already been issued:

WASHINGTON, D. C.

JUDD & DETWEILER, INC., PRINTERS

1909.

BIOGRAPHICAL MEMOIR OF WILLIAM MORE GABB.

William More Gabb was born in Philadelphia January 20, 1839.* His father, Joseph Gabb, was a salesman in mercantile affairs; and his mother (in regard to whom we have only been able to discover that her maiden name was J. H. More), after the death of his father, carried on the business of a milliner, at 248 Poplar street, near Fourth street. The boy was named after his mother's father, William More.

He was educated in the public schools, and graduated at the Jefferson Grammar School at thirteen years of age. He was admitted to the celebrated "Central High School" of Philadelphia in February, 1853, where he distinguished himself in scholarship, being graduated with the degree of A. B. in February, 1857. Among those of his class to achieve distinction were Henry George, James Morgan Hart, Bushrod W. James, and Gustavus W. Towne (who fell at Chancellorsville during the Civil War, having attained the rank of brigadier-general). Some years later he received the master of arts degree from his Alma Mater.

The professor of natural philosophy and chemistry at the school during Gabb's course was Martin Hans Boye, from whom the scientific tastes of young Gabb probably received some stimulation, as he alone represented natural science in the faculty of that day. Although he took the classical course, Gabb had already shown much interest in natural history, conchology, and mineralogy, and, by saving his small pocket money and by gift, had gathered a small collection of elementary books and mineral specimens, from which, as well as from his chemical lessons, he probably acquired some knowledge of blowpipe analysis and of minerals. It is recorded by Dr. Brewer that Gabb spoke of his pleasure as a boy in frequenting the Museum of the Academy of Natural Sciences.

How it happened that, in days when science seemed to offer no career to the young man without independent financial resources,

*In several of the brief biographical notices which have been printed the date is erroneously given as January 16 or 17.

Gabb was permitted to follow his natural bent is a mystery. The father's name disappears from the city directory in 1853, when it is replaced at the same address by "J. H. Gabb, milliner," and the inference might be drawn that the father died at that date and the boy became dependent upon his mother, whose maternal love and pride at his brilliant course in the high school were more impressible by the boy's ambitions than a business-like father might have been. There is mention in a post-card by Dr. George H. Horn, after Gabb's death, of a nephew then living. As no reference to a brother has been found, this nephew was probably a sister's son whose name we have been unable to trace. We know that he had a sister, to whom he was much devoted and who married.

Dropping speculation, our next definite information is to the effect that after graduation, in 1857, Gabb determined to pursue a scientific career in the line of geology and mineralogy. He sought the aid of Professor James Hall, of Albany, New York, then the most distinguished geologist in America, and for a certain period, not definitely stated, he served as assistant and pupil to the Professor. In 1860 he was back in Philadelphia, where, having been admitted to membership in the Academy of Natural Sciences, he became a frequenter of its collections, then the finest in America, and was brought into more or less intimate association with Conrad and other scientific collaborators of the Academy, and served on the committee having charge of the paleontological collections.

About this time, perhaps at the suggestion of Professor Spencer F. Baird, Gabb visited the Smithsonian Institution in Washington, and was one of the group of young scientific students domiciled among the brown Elizabethan towers of the recently erected building. Stimpson, Gill, Hayden, Meek, Horn, Cope, Kennicott, Cooper, and others whose names are now famous were then comrades and fellow-students, shortly to be scattered to the uttermost limits of the continent; but even a brief sojourn among them would have been something to remember for a lifetime. The inspiration of such an experience meant much to the young, eager, ambitious, able, and self-confident student, who had already, in Philadelphia, become known to some members of the coterie.

He had become particularly intimate with the late George H. Horn, who coöperated with him in the preparation of important paleontological memoirs published by the Academy. Another near friend was the late George W. Tryon, Jr., expert in music and conchology. Their influence may have led him finally to specialize in paleontology, though Horn became distinguished later as an entomologist.

In 1860 the California State Geological Survey was authorized, and Josiah Dwight Whitney was named as Geologist. He proceeded in the winter of 1860-'61 to organize the force, which took the field in December, 1860, and the season of 1861 was fully utilized.

The following notes in regard to Gabb's experiences with the State Geological Survey of California, during 1862 and 1863, are from data furnished by Professor W. H. Brewer, of New Haven, who was a member of the Survey staff, and to whom I am much indebted for his kind communications on the subject, his health not permitting him to prepare this memoir personally, as was at first contemplated.

The work of the Survey during 1861 was in the Coast Ranges west or south of the valley of California, and extended from Temescal, south of San Bernardino, northward to Mount Saint Helens, north of San Francisco Bay. The great importance of the Cretaceous rocks, so largely developed in this part of the State, made it very important to engage the services of a qualified paleontologist familiar with the Mesozoic faunas. On Professor Brewer's return to San Francisco, near the end of the year 1861, he was informed by Professor J. D. Whitney, the Director of the Survey, that, after much inquiry, he had engaged a young man who had been recommended to him by competent judges as the best authority in America on Cretaceous paleontology, and as one possessing a good general knowledge of the science in its broader relations.

Gabb left the East and reached San Francisco by steamer from the Isthmus on the morning of January 6, 1862. He was met by Brewer, who conducted him to the offices of the Survey and introduced him to the other members of the staff. The annual meeting of the California Academy of Natural Sciences happened to be set for the evening of the same day, and Gabb accompanied

Brewer to the meeting, was introduced to the little group of scientific men who made up the membership, and was elected not only a member, but also to the Curatorship of Paleontology. It was a cordial greeting to the young scientist, in true California fashion.

Professor Brewer notes that this winter was the wettest that California had experienced since the American occupation of the territory, and the floods very disastrous. The streets of Sacramento, the State capital, were passable only for boats during three months, and the damage to property was commonly estimated at fifty millions of dollars. The Survey was also affected, as the difficulty of getting about was enormously increased, and appropriations were naturally cut down by the legislature, in view of the general losses and reduced taxation.

Gabb worked with great industry, during the early part of 1862, on the fossils which had already been accumulated in the office of the Survey, but took the field with the main party about the last of April, remaining about two months. They visited the northern portion of the Mount Diablo range and worked along its eastern slope for some one hundred and fifty miles. This is one of the most interesting regions in the State for a student of the Cretaceous rocks. These occur at high inclinations over some portions of the region, but are here found in many variable relations, contain its most important coal seams, and exhibit their greatest observed thickness.

During 1861 and 1862 the Survey had studied the geological column from the Cretaceous downward and from the Miocene upward, but no trace of Eocene had been discovered. The only Eocene reported by any observer had been a few fossils, collected by Newberry on the Pacific Railway survey, which were said to be from Fort Tejon.

Doctor Brewer informs me that in 1863 he and Gabb started together on horseback to investigate the region about Fort Tejon for Eocene rocks. Their only baggage was carried in their saddlebags and blanket rolls. Leaving San Francisco early in the spring, they had a tedious ride of more than three hundred miles before reaching Fort Tejon, which was at that time unoccupied by the army. Some settlers were in the vicinity and the main route to Los Angeles crossed the pass. After searching for some

time without satisfactory results, a clue was obtained from a teamster who had accompanied Newberry's party and who claimed to have found the Eocene boulder in the bed of a stream, somewhere between the Fort and the Tejon Indian Reservation, about twenty miles distant. The searchers then rode along the foothills, examined the wash from the various streams, found a single boulder in one, and then went to the Indian reservation. Here two days were spent without success, and the party returned by a slightly different route. Finally, in the ravine called the "Cañada de los Uvas," the beds were detected from which the original boulders may have been derived. Here the desired material was collected.

They then went through the mountains to the San Emidio Cañon, which they explored; thence by the plains to Fort Tejon; across the mountains to the Mojave Desert, which they crossed near its western edge; to the southern part of the Sierra Nevada, and, by way of the Tehachipi Pass (now used by the Southern Pacific Railway), to the great Central Valley again. The Indians on the way had risen in revolt, so the party turned eastward again into the Sierra, working easterly and northerly until the Kern River was reached at Kernville, the Indians being hostile for the whole distance. Gabb and Brewer then worked across the range through Walker Pass and along the eastern base of the Sierra until driven back again by Indians on the warpath. Returning to Kernville, they followed the Central Valley of California northward until they met the party taken by Whitney into the Sierra in June. The expedition was exceedingly interesting and profitable to science, but one which involved much hardship, some danger, and required zeal and courage to accomplish. As a sample of the experiences of the early geological explorers in California, Professor Brewer's notes have seemed worthy of preservation in full.

In the autumn Gabb was sent to investigate the Cretaceous rocks of Oregon, Washington Territory, and Vancouver Island, an expedition to which he devoted three months.

In the intimacy of such a journey as that taken by Professor Brewer, the character of one's companion is usually shown in its true colors. Professor Brewer expresses his recollections of Gabb to the following effect:

What made the strongest impression was that, although strikingly diligent and enthusiastic, he was curiously self-contained. He never seemed afraid and never anxious in the presence of danger; he never lost his temper, and in various ways showed a peculiarly even disposition.

Although as a greenhorn in frontier life he was at first subjected to much chaffing from those members of the party who were more experienced in camp work in California, he never became angry. He took the jokes due to his inexperience, although they were frequent, good naturedly and never exhibited annoyance. He was one of the most diligent of men. If he returned from an expedition of a month or six weeks, and in getting from the field to the office had an hour to spare, that hour was spent with pencil in hand sketching and studying his specimens as if he had not been away.

His relations with his associates were most pleasant. Though his chief was a testy and not tactful man, he greatly appreciated Gabb's work, and in subsequent years did all he could to aid him in various ways.

The writer may add to these personal reminiscences, from his own recollections of 1865 and later years, a few words on Gabb's physical characteristics. He was of moderate height, slender, of sanguine temperament, brown haired, with brilliant dark eyes, a rosy though sunburned complexion, quick in his movements, confident in his bearing, and with a pleasantly harmonious voice. His mistakes, and he occasionally made them, were almost always due to over-confidence, but were acknowledged with a manly frankness. He was considerate of his friends, and his disposition, generous but not lavish, was the result of economical habits forced upon him by the struggles of his early years.

His long absences cut him off in the latter part of his life from intercourse (except at rare intervals) with his scientific colleagues. The only relative who long survived him was a nephew, whose name we have not been able to trace, and the early death of most of those intimately associated with him during his most active years all combined to make the gathering of data regarding his life a matter of no little difficulty.

In 1864 he was sent by Whitney to explore northern Califor-

nia and southeastern Oregon, leaving the northern end of Klamath Lake June 20 and continuing in the field until the middle of October. During this season one of the slate peaks, believed to be nearly 10,000 feet in height and situated in the northeastern angle of Fresno County, California, between the forks of the San Joaquin River, was named Mount Gabb by Whitney.

Paleontological material had now accumulated in abundance, and a large part of 1865 was devoted by Gabb to working up the fossils, the field, except for a little work by Conrad and Trask, being almost unexplored. As Gabb had a neat, artistic faculty, he prepared his own drawings of the fossils, which were afterward engraved and published in the paleontological volumes issued by the Survey.

In 1866 Gabb was engaged from January until November in the exploration of the Coast Ranges and the fossiliferous Tertiary beds of which they are in part composed.

In 1867, at the personal charge of Professor Whitney, Gabb explored the White Mountain Range on the borders of California and Nevada, carrying the work eastward as far as the 116th meridian west of Greenwich, and including a large part of the area between 37° and 39° north latitude, and returned about the end of October.

Certain interests in California having turned their attention to Lower California, an expedition was organized in this year with the consent of the Mexican authorities. It was placed in command of the well-known J. Ross Browne, who associated with himself Ferdinand von Löhr, and, by arrangement with Whitney, W. M. Gabb. The party went to Cape Saint Lucas, and from thence worked northward and in zigzags across the narrow peninsula for the greater part of its length.

Xantus, Guillemin, and Combier had, at various times previously, contributed to the exploration of the peninsula, which was, however, very imperfectly known. To the work of Gabb, trained under such a master as Whitney, and associated with Clarence King, Richthofen, and Ashburner, is due the unveiling of the true structure of the peninsula. This was shown clearly in his map, published in the Geographische Mittheilungen of Petermann; by a chapter in the U. S. Treasury Report on Mineral Resources, 1868, edited by J. Ross Browne; and lastly by his own report, published by Whitney in 1882.

Early in 1868 Gabb returned to the East and gave a summary of his researches in an address before the National Academy of Sciences at its Northampton meeting, in August, 1868.

After seeing the second volume of the California Paleontology through the press, Gabb severed his connection with the Survey. The government of Santo Domingo desired to know something of its geological resources, and made an arrangement with the Santo Domingo Land and Mining Company, a corporation formed in New York for the purpose, whereby that company was to be reimbursed in land for the cost of the survey. The negotiations having been concluded, the diplomatic agent of the Dominican government in the United States selected Mr. Gabb as chief of the survey, which was topographical and geological.

The work began early in 1869, and was carried on for three years with excellent results. A fine map of the country was prepared and united with Schomburgk's Haitian Surveys to form a complete reconnaissance of the island.

He returned to Philadelphia in 1872 to prepare his report and map, and subsequently made a second visit to the island.

In 1873 the government of Costa Rica, in connection with plans for a railway, desired topographical and geological surveys in its little-known province of Talamanca, and engaged the services of Mr. Gabb for the purpose. During three years, while engaged in this work, Gabb extended his observations over a great part of Costa Rica, collected largely in natural history, geological, and ethnological lines, and sent valuable collections to the Smithsonian Institution. He suffered severely from "calentura," or coast fever, a pernicious and deadly form of malaria, and, from exposure in the field, finally contracted pneumonia. This weakened his lungs to an extent which made him an easy victim of the tubercular disease which was later to prove fatal.

He returned to the United States in the spring of 1876, and at the Centennial Exposition at Philadelphia prepared for the *New York Herald* an interesting and valuable report on the mineralogy of the Centennial exhibits. He was elected a member of the National Academy of Sciences in this year.

Not long afterward he returned to Santo Domingo with the intention of developing a promising mining claim. The climate of the country proved unfavorable to him. His disease made

rapid progress, and in a vain fight for life he returned to the United States in April, 1878. His condition was such that the most serious consequences seemed inevitable. He passed the few remaining weeks of his life in endeavoring to make part of his manuscripts available for publication.

These were delivered to the custody of his friend Mr. Tryon, and on the 30th of May, 1878, he died at his home in Willington street, Philadelphia, leaving an aged mother and a nephew to survive him. He was buried June 3, at Woodland Cemetery, near Philadelphia.

His valuable collection of fossils from Santo Domingo and Costa Rica was bequeathed to the Academy of Natural Sciences of Philadelphia. His books and papers were mostly disposed of by sale, but we have found allusions to a diary which was left to his family and which should contain interesting records of his varied experiences as an explorer in tropical lands.

Beside membership in the Academy of Natural Sciences, the American Philosophical Society, and the Academy of Fine Arts of Philadelphia, his merits were recognized by honorary or corresponding membership in various foreign scientific societies. His energy in work and devotion to research are exemplified by his numerous publications and by his persistent exploration of unhealthy regions, where the most elementary comforts of civilization were absent or obtained with difficulty.

Beside the more serious works enumerated in the accompanying bibliography, Gabb contributed letters, describing his experiences in Lower California, to the *Alta California* newspaper of San Francisco. He contributed at times to *Harper's Weekly*, and prepared a description of Costa Rica for *Harper's Magazine*.

In his early publications, Gabb's attention was chiefly devoted to the fossils of the Cretaceous period, of which he rapidly acquired a thorough knowledge, so far as the forms found in the New World were concerned.

During his period of activity he was probably the most proficient and prominent student of the American Cretaceous.

While working on the paleontology of California he monographed the Upper Mesozoic and Tertiary, so that his works, which at the time formed the standard for reference on the subject, must always remain classics for the student of these forms.

His work in Lower California, Santo Domingo, and Costa Rica was of serious importance for geography; the paleontologic work actually published was of a preliminary character, but the complete monographs which he contemplated and for which he had gathered much material were destined never to be written.

The amount he accomplished in the brief space of eighteen years, during five of which he was more or less constantly suffering from the enervating effects of tropical malaria, is worthy of respect and admiration, mingled with regret that his life was not spared to complete the researches he contemplated and which he was so well fitted to carry out.

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American Journal of Science, 3d ser., XVI, 1878, p. 164 (by Doctor J. S. Newberry).

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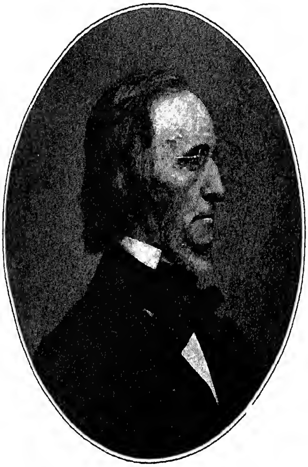


Alexis Caswell.

NATIONAL ACADEMY OF SCIENCES
BIOGRAPHICAL MEMOIRS
PART OF VOLUME VI

BIOGRAPHICAL MEMOIR

OF

ALEXIS CASWELL

1799-1877

BY

JOSEPH LOVERING

Reprinted from the Proceedings of the
American Academy of Arts and Sciences, Philadelphia

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
April, 1909

NATIONAL ACADEMY OF SCIENCES.

Of the biographical memoirs which are to be included in Volume VI, the following have already been issued:

WASHINGTON, D. C.
JUDD & DETWEILER, INC., PRINTERS.
1909.

BIOGRAPHICAL MEMOIR OF ALEXIS CASWELL.*

On the 8th of January, 1877, Rhode Island lost, by death, an accomplished man of science and one of her best citizens. Alexis Caswell was born in Taunton, Mass., on the 29th of January, 1799. His ancestors on the father's side were prosperous farmers, and were among the earliest settlers of Taunton. Thomas Caswell, of the fifth generation preceding, came, according to tradition, from Somersetshire, England. His will was admitted to probate in 1697, only fifty-eight years after the incorporation of Taunton. The grandfather of Alexis married Zibiah White, who was the great-granddaughter of Peregrine White, the first-born of the Pilgrims in America on board the *Mayflower*, November, 1620. Alexis Caswell, after spending his early years upon the farm, was prepared for college at the Bristol Academy, in Taunton. Little is known of his character and attainments at this time; but, if the child is father of the man, he must have been amiable, docile, and full of high ambition. At the age of nineteen he entered Brown University, over which Dr. Messer then presided. His course in college was eminently successful, and at his graduation in 1822 he received the first honors.

From 1822 to 1827 he was connected with Columbian College, Washington, D. C., as tutor or professor of languages, at the same time studying theology under Dr. Stoughton, the president. In the autumn of 1827 he went with Dr. Irah Chase (professor in the Newton Theological Seminary from 1825 to 1843) to Halifax, for the purpose of establishing the Granville Street Baptist Church in that place. His plans were changed in consequence of an invitation which he received from the people to remain among them. He was ordained on the 7th of October, and settled over them as their pastor. Having preached to them acceptably for a year, he received an invitation from the First Baptist Church in Providence, in the summer of 1828, to assist

*Reprinted from the Proceedings of the American Academy of Arts and Sciences, Philadelphia, Vol. XII, 1877, pp. 307–313.

the Rev. S. Gano, the pastor of that church. He had been in Providence only a few weeks when he was appointed professor of mathematics and natural philosophy in Brown University. With the exception of the time when he visited Europe, in 1860-1861, he discharged the laborious duties of this office for thirty-five years, to the complete satisfaction of the government and the pupils of the institution. Engaging in its instruction soon after Dr. Wayland's accession to the presidency, he was his strong support throughout an able and vigorous administration. In many respects one was the fitting complement of the other, and respect and confidence were felt equally on each side. In 1840, while Dr. Wayland was absent in Europe, Professor Caswell discharged the duties of president; and, during the last three years of President Wayland's official term, Professor Caswell, under the title of regent, relieved him from all the anxieties of discipline, bringing to this delicate duty qualities of mind and heart which secured good order without alienating the affection of the students.

When Dr. Caswell resigned his professorship in 1863 he was sixty-four years of age, and had fairly earned the leisure and the retirement which are the reward and luxury of old age. But he was still young in the best sense of the word—young in his feelings, in his habits of industry, in his intellectual faculties, in the good constitution which he had inherited from his father (who died in 1851 at the advanced age of ninety-one), and young in his passion to serve his day and generation to the end. Accordingly he engaged in active affairs with a vigor and success which younger men might well have envied. Refreshed by five years, not of repose, but of a change of his intellectual diet, he again obeyed the voice of his Alma Mater, which called him, in 1868, to the presidency of Brown University, Dr. Sears, his predecessor, having been summoned to an urgent and difficult service by the strong voice of patriotism and humanity. Although Dr. Caswell had been moving for a few years outside of the university domain, his heart was always there. He knew, better probably than any one else, the wants, the resources, and aims of the institution; and, notwithstanding that he stood on the brink of threescore years and ten, he brought to his high position the vigor, the freshness, and the hope of youth. Among the

various needs of the university which he pressed upon the attention of the corporation in his annual reports was the establishment of an astronomical observatory, sufficient for the purposes of instruction if not of research.

Soon after leaving the office of president, in 1872, Dr. Caswell was elected into the board of trustees, and in 1875 he was chosen a fellow of the corporation. In 1841 he received the degree of D. D., and in 1865 that of LL. D., both from his own university. For nearly fifty years he had been associated with it, either as student, teacher, president, trustee, or fellow, and in each and all of these relations he had reflected back all the honors which he had received as a favorite son. Earnest, devoted, and generous himself, he had the power and the disposition to enlist others of larger means in the same cause. None of its distinguished children has exceeded him, perhaps none has equaled him, in length of service and fidelity to its sacred trusts.

The special function and the high delight of Dr. Caswell were those of an educator. When he began his profession of teacher he shared the fate of his contemporaries in older and richer universities in a new country. He was responsible for all the instruction given in mathematics and natural philosophy; in fact, he alone represented the scientific side of the institution to which he was attached. Afterwards, a professor of chemistry, and at a much later period professors of natural philosophy or mathematics, were associated with him, so that in 1850 his own duties were restricted to astronomy, from 1851 to 1855 to mathematics and astronomy, and after 1855 to natural philosophy and astronomy. It could not be expected of any man who was required to scatter his energies over a variety of subjects, which in a well appointed university would tax the best efforts of half a dozen professors, that he should have much leisure or disposition for original investigation in one direction. It was enough, and more than enough, for the most laborious and ambitious teacher that he should maintain a high standard of scholarship in the wide field which circumstances forced him to cultivate. Much has been written during the last few years in regard to the endowment of scientific research. But this is a luxury of which no one dreamed in Dr. Caswell's day, and its strongest advocates at the present time are not in agreement as to the best way of

accomplishing the desirable result. Mr. Huxley may be correct in his opinion that a moderate amount of teaching will not check, but stimulate, the zeal of the original explorer; but no one will think that a mind wearied by excessive teaching, distracted by a multiplicity of topics, and prevented from rising in his instruction to the Alpine heights of science by the dullness or indifference of the average student who despairs even of reaching the table-land, is a congenial soil for advancing human knowledge. Under such circumstances, one of two things must happen—either the work of teaching will be neglected or that of original research will be left to men more favorably placed.

It must not be inferred from these remarks that Dr. Caswell was contented to remain stationary. At no time since his scientific life began has it been an easy task even to keep in sight the few who are steadily advancing the outposts of science, and of late it is quite impossible without concentration. Dr. Caswell's predilection was for meteorology and astronomy. During the period of twenty-eight and a half years (from December, 1831, to May, 1860) he made, with few interruptions, a regular series of meteorological observations at the same spot on College Hill, in Providence. These observations, precise as regards temperature and pressure, and including also much information on winds, clouds, moisture, rain, storms, the aurora, &c., have been published in detail in Vol. XII of the "Smithsonian Contributions to Knowledge," and fill 179 quarto pages. Dr. Caswell continued his observations in meteorology with unabated zeal to the end of 1876, covering, in all, the long period of forty-five years. It is to be hoped that the latter portion of the series will be published soon under the same favorable auspices as the former. If it be true, as the Astronomer Royal of Greenwich believes, that meteorology is in too crude a state to claim the rank of a physical science, such labors as those of Dr. Caswell are among the means of making it one. And certainly, at this moment, the interests and hopes involved in the subject are beyond anything which Dr. Caswell could have imagined when he began his work. Dr. Holyoke's meteorological observations in Salem (published in the Memoirs of this Academy*) began in January, 1786, and con-

*The American Academy of Arts and Sciences, Philadelphia.

tinued to March, 1829. Mr. Hall's observations in Boston (also published in the Memoirs of the Academy*) embrace a period of forty-nine years, viz., from 1821 to 1865. The observations of Dr. Hale, also made in Boston, between 1817 and 1848, are preserved in the archives of the Academy* for future publication. These various series, arranged in sequence, may answer the question, What changes has a century brought to the climate of New England? So far as the observations are contemporaneous, they will indicate the amount of influence to be ascribed to local causes or instrumental defects.

In 1858 Dr. Caswell delivered four lectures on astronomy at the Smithsonian Institution in Washington. They were of the highest order of popular instruction, and on that account were thought by Professor Henry worthy of being permanently preserved in his printed report for that year. Whatever may have been or may still be the conflict between science and theology, there is no conflict between science and religion, least of all in Dr. Caswell's mind. He says in his introductory remarks: "The mechanism of the heavens, in proportion as we comprehend more and more of its vastness and seeming complexity, bears witness to the enduring order and harmony of the universe, and points with unerring certainty to the superintending agency of an intelligent and infinite Creator." And again: "We spontaneously pay the tribute of our homage to all great achievements. But in no case is homage more just or more enduring than that which all cultivated minds pay to him who stands as the minister and interpreter of Nature, and makes known to us her laws and her mysteries. Many such adorn the annals of astronomy."

Dr. Caswell joined the American Association for the Advancement of Science at its second meeting, which was held at Cambridge in 1850. Although he made no formal contribution to its proceedings, he was a frequent attendant upon the annual meetings, took part in the discussions, and always gave dignity to its deliberations by his character and his words. In 1855 the Association had its ninth meeting in Providence, and the hospitable reception then given to it and the hearty appreciation felt for its labors were largely due to his influence. The members ex-

*The American Academy of Arts and Sciences, Philadelphia.

pressed their gratitude for this service by electing him as the vice-president for the next meeting, in Montreal; but the death of the president-elect, Professor J. W. Bailey, of West Point, called Dr. Caswell to the chair. At this large representation of the science of the continent (the only meeting which has taken place outside of the limits of the United States) he sustained the credit of his country on a foreign soil by his dignified presence and his manly eloquence, to the great satisfaction of all his associates. At such a time and in such a position Dr. Caswell appeared to great advantage. By his dignity, his address, and his courtesy he was eminently qualified to be a presiding officer; and he was gifted with a fluency, a felicity, and a weight of speech which rose to the requirements of the occasion. At the next meeting of the Association, in Baltimore, the president and vice-president-elect were absent, and every hand was uplifted in favor of placing Dr. Caswell again in the chair. Having been called to preside over two of the most brilliant gatherings of this scientific body, he was expected to discharge the last duty of a retiring president by giving the address at Springfield. After showing that science had an intellectual value far transcending its practical use, he discussed the objects, the opportunities, and the hopes of science in America, drawing his illustrations chiefly from astronomy, partly because it was his favorite study and partly because it had the start of all others in material resources. In this excellent address, admirable in thought, spirit, and style, Dr. Caswell reiterates his conviction that genuine science is not unfriendly to religion. "We participate in no such fear. We wish explicitly to exonerate this Association from all suspicion of undermining, or in any manner weakening, the foundations of that faith which an apostle says was once delivered to the saints. We cannot admit the opinion that any progress in science will ever operate to the disparagement of that devout homage which we all owe to Him in whose hand our breath is, and whose are all our ways. Science, on the contrary, lends its sanction and adds the weight of its authority to the sublime teachers of revelation."

In this connection, two other scientific publications of Dr. Caswell may be mentioned: I. On Zinc as a Covering for Buildings; "American Journal of Science," 1837; II. Review of

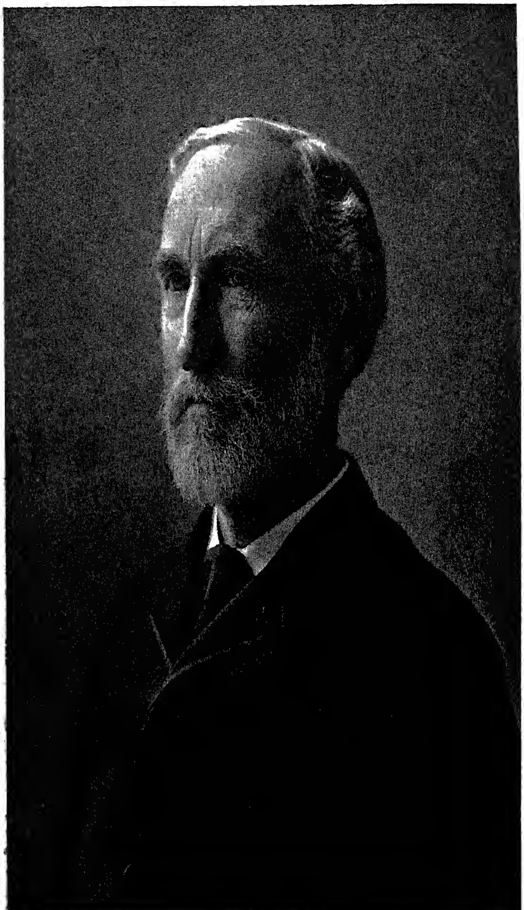
Nichol's Architecture of the Heavens; "Christian Review," 1841. Dr. Caswell was elected an Associate Fellow of this Academy* in 1850. He was one of the original members of the National Academy of Sciences. He wrote for that body a memoir of that worthy pioneer in American science, Benjamin Silliman, which has been printed in one of its volumes of Proceedings.

In this retrospect of the life and labors of Dr. Caswell he has been seen almost exclusively in his professional relations as the student and teacher of science. And here his mind took more delight in ranging over a wide field than in dissecting some single flower or tracing the path of a solitary molecule, although that may be a microcosm in itself. He could not have become one of Berkeley's minute philosophers. He was no specialist, though he was never superficial. If he was not himself an original discoverer, he understood and admired the discoveries of others, and led others to do likewise. At one time he taught Butler's Analogy at the university, and with as fresh an enthusiasm as if that alone had been the chosen work of his life. And wherever there was a gap in the means of instruction, he was the person thought to be fitted to fill it. His whole nature revolted at the suggestion of becoming a book-worm or a secluded student. He was emphatically a man of the world, though not of it. He was interested in trade, manufactures, and finance. He was a good citizen, and took an active part in promoting the industrial, intellectual, and moral welfare of his city, his State, and the whole country. His sympathies were deep and generous. Always welcomed in the circles of the refined and educated, he will be no less missed in the homes of the poor and the unfortunate. His heart and mind and strength were liberally expended in the administration of the public charities of the city and State.

Dr. Caswell was an earnest speaker, and a clear, warm, and vigorous writer. To his publications already mentioned may be added: I. Φ B K oration in 1835. II. Review of Whewell's Bridgewater Treatise; "Christian Review," 1836. III. Article on Emulation; "North American Review," 1836. IV. Address at the funeral of Rev. J. N. Granger, 1857. V. Memoir of John Barstow. VI. Sermon on the Life and Christian Work of Dr. Francis Wayland.

*The American Academy of Arts and Sciences, Philadelphia.

Truly was it said of Dr. Caswell, at his funeral, that nature did much for him, but that grace had done even more. Firm and earnest in his own religious convictions, inflexible in his own peculiar theology, he had no taint of illiberality in his intellect or his heart, ever abounding in that Christian charity which thinketh no evil of any who conscientiously worshiped the same God from a different altar. He had mingled in the affairs of practical life more than usually happens to an academic career, but the purity, the integrity, and the simplicity of his character were superior to its surroundings, and to the end he seemed as much in place in the pulpit as if he had never left the profession of his early choice. There was no austerity in his goodness; hence it attracted those who could not have been driven. Sweet in temper, cheerful in disposition, gentle, affectionate, affable, hospitable, he was happy in his life, and even more happy in his death. After his long day, in which he had not labored in vain, his sun went suddenly down in a cloudless sky. And behold the end of such a man: it is all honor, and affection, and peace. The press, the university, the church, and the State have borne witness to the excellence of his character and the usefulness of his life.



Verlag von Wilhelm Engelmann, Leipzig. Meisenbach Riffarth & Co, Leipzig.

J. Willard Gibbs

NATIONAL ACADEMY OF SCIENCES
BIOGRAPHICAL MEMOIRS
PART OF VOLUME VI

BIOGRAPHICAL MEMOIR

OF

JOSIAH WILLARD GIBBS

1839-1903

BY

CHARLES S. HASTINGS

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
May, 1909

NATIONAL ACADEMY OF SCIENCES.

Of the biographical memoirs which are to be included in Volume VI, the following have already been issued:

WASHINGTON, D. C.

JUDD & DETWEILER, INC., PRINTERS.

1909.

BIOGRAPHICAL MEMOIR OF JOSIAH WILLARD GIBBS.

JOSIAH WILLARD GIBBS was born in New Haven, February 11, 1839, and died in the same city on April 28, 1903; and New Haven remained his home during his whole life, for the only long absence from it was that of his period of study in France and in Germany which immediately followed his early experience as a teacher. Thus he was peculiarly identified with the intellectual life of New Haven and of Yale University, for no part of his education could have been regarded as uninfluenced by that ancient institution which, for the long period of thirty-seven years, counted his father a member of its faculty and which has always been dominant in shaping the methods of the Hopkins Grammar School, where his earlier studies were pursued. From this school he entered college in 1854, and received his bachelor's degree in 1858 with a record of distinction in Latin and in Mathematics. For five years after graduation he pursued studies in his chosen field, acquired the honor of a doctorate in 1863, and accepted an appointment as tutor in Yale College. That he taught Latin for two years and Natural Philosophy for the third and last of the years in which he retained this position should not lead one to think that his tastes at that time were unformed, nor that they were equally divided between two fields of thought so diverse. It is to be looked upon rather as a curious illustration of a former condition in our higher institutions of learning, when every distinguished graduate was supposed equally capable of teaching any subject pursued by undergraduates. At the end of the period of appointment he went to Europe for study, passing the winter of 1866-7 in Paris and the following year in Berlin. In 1868 he was in Heidelberg; and he returned to New Haven in 1869. Two years later he received an appointment to the professorship of Mathematical Physics in Yale College, a position which he retained until his death.

Professor Gibbs, during his first year in this newly established chair, had only two pupils, both now professors in Yale University and both members of the Academy. In the

choice of work for this little class he was absolutely untrammeled either by precedent or by expressed preference of his pupils; hence the character of his teaching possesses a peculiar interest as an indication of the contemporary state of his scientific development which, perhaps, would be sought in vain elsewhere. The text of his choice was the Traité de Mécanique of Poisson, and the works most frequently quoted were those of Fresnel and of Cauchy. His lectures were for a considerable period confined to an exposition of the theories of Fresnel concerning diffraction, polarization, and the generalized laws of reflection; but this was followed by a remarkably interesting general treatment of waves, which, in successive chapters, was applied to a discussion of various types, such as water waves and those of light at the boundary in cases of total reflection. Long after this period one of his pupils extorted from him a conditional promise that he would publish this work on waves in book form, and it is much to be regretted that he never found a convenient time to do so; but there is little doubt that the insuperable difficulties in the mechanical explanation of double refraction forced themselves upon his mind at this time and turned his attention in a direction which led him later to his powerful support of the electro-magnetic theory of light. Certain it is that at this period of 1871-2 Professor Gibbs showed his chief interest in the domain of physical optics, and that his inspirations from without were derived from the French school of philosophers rather than from the German.

In the following year, 1872-3, Professor Gibbs chose a little work by Clausius, on the potential theory, as the basis of his lectures, a fact which is worth recording because it indicates that he had become acquainted with the writings of a physicist whose work he was shortly to extend in so remarkable a manner; for it was in April and May of 1873 that he presented before the Connecticut Academy the first of the papers on the mechanics of heat which have established his eminence for all time; and the immediate object of the paper, entitled "Graphical Methods in the Thermodynamics of Fluids," was to exhibit the fruitfulness of the conception of entropy, introduced by Clausius.

It is not a little singular that a man of such transcendent intellectual gifts, and one whose tastes for physical science were so

pronounced, should have exhibited no desire to publish the results of his studies until he had attained such maturity; but from this epoch until his death, few years passed without his having contributed a paper of lasting importance either to physical science or mathematics. Perhaps the fact that the name of Professor Gibbs did not recur with greater frequency in current scientific literature caused some of his contemporaries to hold a false opinion of his fertility, but an inspection of his collected papers* would dispel every such impression. The exhaustive thoroughness with which every subject of his studies is there treated, as well as the absolute extent of his longer papers, imply vast and systematic industry.

The publication of these volumes brought forth many reviews and critical comments on the life and works of this eminent scholar from some of the leading physicists of the world;† but no one has been so advantageously situated or so successful in a general review of the aims and scope of these recondite papers as Professor Henry A. Bumstead. For years a follower of the later lectures of Professor Gibbs, he became afterward a colleague and a joint editor with Dr. Ralph Gibbs Van Name of the two volumes of collected papers; and it is not probable that any later writer on this subject will be able to add greatly to the extended and sympathetic review which prefaces the first volume of the Scientific Papers, nor would any admirer of the eminent scientist desire to see it curtailed. It reads as follows:

*The Scientific Papers of J. Willard Gibbs. Longmans, Green & Co., London, New York, and Bombay; 2 volumes, 8°, 1906.

†Reference may be specifically made to the following:

Professor Joseph Larmor, London Times, Literary Supplement, March 22, 1907.

Professor C. S. Peirce, The Nation, January 7, 1907.

Professor J. H. Jeans, American Journal of Science, February, 1907.

An unnamed writer in the Bulletin des Sciences Mathématique; Aout, 1907.

Besides these appeared numerous shorter notices in the current Journals of that year devoted to physics and to mathematics.

With this list might be mentioned the earlier memorial essay on Josiah Willard Gibbs, by Professor C. Alasia, in the Revista di Fisica, Mathematica, e Scienza Naturali; Pavia, 1905.

It was not until 1873, when he was thirty-four years old, that he gave to the world, by publication, evidence of his extraordinary powers as an investigator in mathematical physics. In that year two papers appeared in the Transactions of the Connecticut Academy, the first being entitled "Graphical Methods in the Thermodynamics of Fluids," and the second "A Method of Geometrical Representation of the Thermodynamic Properties of Substances by Means of Surfaces." These were followed in 1876 and 1878 by the two parts of the great paper "On the Equilibrium of Heterogeneous Substances," which is generally, and probably rightly, considered his most important contribution to physical science, and which is unquestionably among the greatest and most enduring monuments of the wonderful scientific activity of the nineteenth century. The first two papers of this series, although somewhat overshadowed by the third, are themselves very remarkable and valuable contributions to the theory of thermodynamics; they have proved useful and fertile in many direct ways and, in addition, it is difficult to see how, without them, the third could have been written. In logical development the three are very closely connected, and methods first brought forward in the earlier papers are used continually in the third.

Professor Gibbs was much inclined to the use of geometrical illustrations, which he employed as symbols and aids to the imagination, rather than the mechanical models which have served so many great investigators; such models are seldom in complete correspondence with the phenomena they represent, and Professor Gibbs's tendency toward rigorous logic was such that the discrepancies apparently destroyed for him the usefulness of the model. Accordingly he usually had recourse to the geometrical representation of his equations, and this method he used with great ease and power. With this inclination, it is probable that he made much use, in his study of thermodynamics, of the volume-pressure diagram, the only one which, up to that time, had been used extensively. To those who are acquainted with the completeness of his investigation of any subject which interested him, it is not surprising that his first published paper should have been a careful study of all the different diagrams which seemed to have any chance of being useful. Of the new diagrams which he first described in this paper, the simplest, in some respects, is that in which entropy and temperature are taken as coördinates; in this, as in the familiar volume-pressure diagram, the work or heat of any cycle is proportional to its area in any part of the plane; for many purposes it is far more perspicuous than the older diagram, and it has found most important practical applications in the study of the steam engine. The diagram, however, to which Professor

Gibbs gave most attention was the volume-entropy diagram, which presents many advantages when the properties of bodies are to be studied, rather than the work they do or the heat they give out. The chief reason for this superiority is that volume and entropy are both proportional to the quantity of substance, while pressure and temperature are not; the representation of coexistent states is thus especially clear, and for many purposes the gain in this direction more than counterbalances the loss due to the variability of the scale of work and heat. No diagram of constant scale can, for example, adequately represent the triple state where solid, liquid, and vapor are all present; nor, without confusion, can it represent the states of a substance which, like water, has a maximum density; in these and in many other cases the volume-entropy diagram is superior in distinctness and convenience.

In the second paper the consideration of graphical methods in thermodynamics was extended to diagrams in three dimensions. James Thomson had already made this extension to the volume-pressure diagram by erecting the temperature as the third coördinate, these three immediately cognizable quantities giving a surface whose interpretation is most simple from elementary considerations, but which, for several reasons, is far less convenient and fertile of results than one in which the coördinates are thermodynamic quantities less directly known. In fact, if the general relation between the volume, entropy and energy of any body is known, the relation between the volume, pressure, and temperature may be immediately deduced by differentiation; but the converse is not true, and thus a knowledge of the former relation gives more complete information of the properties of a substance than a knowledge of the latter. Accordingly Gibbs chooses as the three coördinates the volume, entropy, and energy, and, in a masterly manner, proceeds to develop the properties of the resulting surface, the geometrical conditions for equilibrium, the criteria for its stability or instability, the conditions for coexistent states and for the critical state; and he points out, in several examples, the great power of this method for the solution of thermodynamic problems. The exceptional importance and beauty of this work by a hitherto unknown writer was immediately recognized by Maxwell, who, in the last years of his life, spent considerable time in carefully constructing, with his own hands, a model of this surface, a cast of which, very shortly before his death, he sent to Professor Gibbs.

One property of this three dimensional diagram (analogous to that mentioned in the case of the plane volume-entropy diagram) proved to be of capital importance in the development of Gibbs's future work in thermodynamics; the volume, entropy,

and energy of a mixture of portions of a substance in different states (whether in equilibrium or not) are the sums of the volumes, entropies, and energies of the separate parts, and, in the diagram, the mixture is represented by a single point which may be found from the separate points, representing the different portions, by a process like that of finding centers of gravity. In general this point is not in the surface representing the stable states of the substance, but within the solid bounded by this surface, and its distance from the surface, taken parallel to the axis of energy, represents the available energy of the mixture. This possibility of representing the properties of mixtures of different states of the same substance immediately suggested that mixtures of substances differing in chemical composition, as well as in physical state, might be treated in a similar manner; in a note at the end of the second paper the author clearly indicates the possibility of doing so, and there can be little doubt that this was the path by which he approached the task of investigating the conditions of chemical equilibrium, a task which he was destined to achieve in such a magnificent manner and with such advantage to physical science.

In the discussion of chemically homogeneous substances in the first two papers, frequent use had been made of the principle that such a substance will be in equilibrium if, when its energy is kept constant, its entropy cannot increase; at the head of the third paper the author puts the famous statement of Clausius: "Die Energie der Welt ist constant. Die Entropie der Welt strebt einem Maximum zu." He proceeds to show that the above condition for equilibrium, derived from the two laws of thermodynamics, is of universal application, carefully removing one restriction after another, the first to go being that the substance shall be chemically homogeneous. The important analytical step is taken of introducing, as variables in the fundamental differential equation, the masses of the constituents of the heterogeneous body; the differential coefficients of the energy with respect to these masses are shown to enter the conditions of equilibrium in a manner entirely analogous to the "intensities," pressure and temperature, and these coefficients are called potentials. Constant use is made of the analogies with the equations for homogeneous substances, and the analytical processes are like those which a geometer would use in extending to n-dimensions the geometry of three.

It is quite out of the question to give, in brief compass, anything approaching an adequate outline of this remarkable work. It is universally recognized that its publication was an event of the first importance in the history of chemistry, that in fact it founded a new department of chemical science which, in the words of M. Le Chatelier, is becoming comparable in importance

with that created by Lavoisier. Nevertheless it was a number of years before its value was generally known; this delay was due largely to the fact that its mathematical form and rigorous deductive processes make it difficult reading for any one, and especially so for students of experimental chemistry, whom it most concerns; twenty-five years ago there was relatively only a small number of chemists who possessed sufficient mathematical knowledge to read easily even the simpler portions of the paper. Thus it came about that a number of natural laws of great importance which were, for the first time, clearly stated in this paper were subsequently, during its period of neglect, discovered by others, sometimes from theoretical considerations, but more often by experiment. At the present time, however, the great value of its methods and results are fully recognized by all students of physical chemistry. It was translated into German in 1891 by Professor Ostwald and into French in 1899 by Professor Le Chatelier; and, although so many years had passed since its original publication, in both cases the distinguished translators give, as their principal reason for undertaking the task, not the historical interest of the memoir, but the many important questions which it discusses and which have not even yet been worked out experimentally. Many of its theorems have already served as starting points or guides for experimental researches of fundamental consequence; others, such as that which goes under the name of the "Phase Rule," have served to classify and explain, in a simple and logical manner, experimental facts of much apparent complexity; while still others, such as the theories of catalysis, of solid solutions, and of the action of semi-permeable diaphragms and osmotic pressure, showed that many facts, which had previously seemed mysterious and scarcely capable of explanation, are in fact simple, direct, and necessary consequences of the fundamental laws of thermodynamics. In the discussion of mixtures in which some of the components are present only in very small quantity (of which the most interesting cases at present are dilute solutions) the theory is carried as far as is possible from *a priori* considerations; at the time the paper was written the lack of experimental facts did not permit the statement, in all its generality, of the celebrated law which was afterward discovered by van't Hoff; but the law is distinctly stated for solutions of gases as a direct consequence of Henry's law and, while the facts at the author's disposal did not permit a further extension, he remarks that there are many indications "that the law expressed by these equations has a very general application."

It is not surprising that a work containing results of such consequence should have excited the profoundest admiration among students of the physical sciences; but even more remarkable

than the results, and perhaps of even greater service to science, are the methods by which they were attained; these do not depend upon special hypotheses as to the constitution of matter or any similar assumption, but the whole system rests directly upon the truth of certain experiential laws which possess a very high degree of probability. To have obtained the results embodied in these papers in any manner would have been a great achievement; that they were reached by a method of such logical austerity is a still greater cause for wonder and admiration. And it gives to the work a degree of certainty and an assurance of permanence, in form and matter, which is not often found in investigations so original in character.

In lecturing to students upon mathematical physics, especially in the theory of electricity and magnetism, Professor Gibbs felt, as so many other physicists in recent years have done, the desirability of a vector algebra by which the more or less complicated space relations, dealt with in many departments of physics, could be conveniently and perspicuously expressed; and this desire was especially active in him on account of his natural tendency toward elegance and conciseness of mathematical method. He did not, however, find in Hamilton's system of quaternions an instrument altogether suited to his needs, in this respect sharing the experience of other investigators who have, of late years, seemed more and more inclined, for practical purposes, to reject the quaternionic analysis, notwithstanding its beauty and logical completeness, in favor of a simpler and more direct treatment of the subject. For the use of his students, Professor Gibbs privately printed in 1881 and 1884 a very concise account of the vector analysis which he had developed, and this pamphlet was to some extent circulated among those especially interested in the subject. In the development of this system the author had been led to study deeply the *Ausdehnungslehre* of Grassmann, and the subject of multiple algebra in general; these investigations interested him greatly up to the time of his death, and he has often remarked that he had more pleasure in the study of multiple algebra than in any other of his intellectual activities. His rejection of quaternions, and his championship of Grassmann's claim to be considered the founder of modern algebra, led to some papers of a somewhat controversial character, most of which appeared in the columns of *Nature*. When the utility of his system as an instrument for physical research had been proved by twenty years' experience of himself and of his pupils, Professor Gibbs consented, though somewhat reluctantly, to its formal publication in much more extended form than in the original pamphlet. As he was at that time wholly occupied with another work, the task of preparing this treatise for publication was entrusted to one of his

students, Dr. E. B. Wilson, whose very successful accomplishment of the work entitles him to the gratitude of all who are interested in the subject.

The reluctance of Professor Gibbs to publish his system of vector analysis certainly did not arise from any doubt in his own mind as to its utility, or the desirability of its being more widely employed; it seemed rather to be due to the feeling that it was not an original contribution to mathematics, but was rather an adaptation for special purposes of the work of others. Of many portions of the work this is of course necessarily true, and it is rather by the selection of methods and by systematization of the presentation that the author has served the cause of vector analysis. But in the treatment of the linear vector function and the theory of dyadics to which this leads, a distinct advance was made which was of consequence not only in the more restricted field of vector analysis, but also in the broader theory of multiple algebra in general.

Professor Gibbs was much interested in the application of vector analysis to some of the problems of astronomy, and gave examples of such application in a paper "On the Determination of Elliptic Orbits from Three Complete Observations" (Memoirs of the National Academy of Sciences, Vol. IV, Pt. 2, pp. 79-104). The methods developed in this paper were afterwards applied by Professors W. Beebe and A. W. Phillips* to the computation of the orbit of Swift's comet (1880 V) from three observations, which gave a very critical test of the method. They found that Gibbs's method possessed distinct advantages over those of Gauss and Oppolzer, the convergence of the successive approximations was more rapid, and the labor of preparing the fundamental equations for solution much less. These two papers were translated by Buchholz and incorporated in the second edition of Klinkerfues's *Theoretische Astronomie.*

Between the years 1882 and 1889, five papers appeared in the American Journal of Science upon certain points in the electromagnetic theory of light and its relations to the various elastic theories. These are remarkable for the entire absence of special hypotheses as to the connection between ether and matter, the only supposition made as to the constitution of matter being that it is fine-grained with reference to the wave-length of light, but not infinitely fine-grained, and that it does disturb in some manner the electrical fluxes in the ether. By methods whose sim-

*Astronomical Journal, Vol. IX, 1889, pp. 114-117, 121-124.

plicity and directness recall his thermodynamic investigations, the author shows in the first of these articles that, in the case of perfectly transparent media, the theory not only accounts for the dispersion of colors (including the "dispersion of the optic axes" in doubly refracting media), but also leads to Fresnel's laws of double refraction for any particular wave-length without neglect of the small quantities which determine the dispersion of colors. He proceeds in the second paper to show that circular and elliptical polarization are explained by taking into account quantities of a still higher order, and that these in turn do not disturb the explanation of any of the other known phenomena; and in the third paper he deduces, in a very rigorous manner, the general equations of monochromatic light in media of every degree of transparency, arriving at equations somewhat different from those of Maxwell in that they do not contain explicitly the dielectric constant and conductivity as measured electrically, thus avoiding certain difficulties (especially in regard to metallic reflection) which the theory as originally stated had encountered; and it is made clear that "a point of view more in accordance with what we know of the molecular constitution of bodies will give that part of the ordinary theory which is verified by experiment, without including that part which is in opposition to observed facts." Some experiments of Professor C. S. Hastings in 1888 (which showed that the double refraction in Iceland spar conformed to Huyghens's law to a degree of precision far exceeding that of any previous verification) again led Professor Gibbs to take up the subject of optical theories in a paper which shows, in a remarkably simple manner, from elementary considerations, that this result and also the general character of the facts of dispersion are in strict accord with the electrical theory, while no one of the elastic theories which had, at that time, been proposed could be reconciled with these experimental results. A few months later, upon the publication of Sir William Thomson's theory of an infinitely compressible ether, it became necessary to supplement the comparison by taking account of this theory also. It is not subject to the insuperable difficulties which beset the other elastic theories, since its equations and surface conditions for perfectly homogeneous and transparent media are identical in form with those of the electrical theory, and lead in an equally direct manner to Fresnel's construction for doubly-refracting media, and to the proper values for the intensities of the reflected and refracted light. But Gibbs shows that, in the case of a fine-grained medium, Thomson's theory does not lead to the known facts of dispersion without unnatural and forced hypotheses, and that in the case of metallic reflection it is subject to similar difficulties; while, on the other hand, "it may be said for the electrical theory that it is not obliged to in-

vent hypotheses, but only to apply the laws furnished by the science of electricity, and that it is difficult to account for the coincidences between the electrical and optical properties of media unless we regard the motions of light as electrical." Of all the arguments (from theoretical grounds alone) for excluding all other theories of light except the electrical, these papers furnish the simplest, most philosophical, and most conclusive with which the present writer is acquainted; and it seems likely that the considerations advanced in them would have sufficed to firmly establish this theory even if the experimental discoveries of Hertz had not rendered such discussions forever unnecessary.

In his last work, "Elementary Principles in Statistical Mechanics," Professor Gibbs returned to a theme closely connected with the subjects of his earliest publications. In these he had been concerned with the development of the consequences of the laws of thermodynamics which are accepted as given by experience; in this empirical form of the science, heat and mechanical energy are regarded as two distinct entities, mutually convertible of course with certain limitations, but essentially different in many important ways. In accordance with the strong tendency toward unification of causes, there have been many attempts to bring these two things under the same category; to show, in fact, that heat is nothing more than the purely mechanical energy of the minute particles of which all sensible matter is supposed to be made up, and that the extra-dynamical laws of heat are consequences of the immense number of independent mechanical systems in any body—a number so great that, to human observation, only certain averages and most probable effects are perceptible. Yet in spite of dogmatic assertions, in many elementary books and popular expositions, that "heat is a mode of molecular motion," these attempts have not been entirely successful, and the failure has been signalized by Lord Kelvin as one of the clouds upon the history of science in the nineteenth century. Such investigations must deal with the mechanics of systems of an immense number of degrees of freedom and (since we are quite unable in our experiments to identify or follow individual particles), in order to compare the results of the dynamical reasoning with observation, the processes must be statistical in character. The difficulties of such processes have been pointed out more than once by Maxwell, who, in a passage which Professor Gibbs often quoted, says that serious errors have been made in such inquiries by men whose competency in other branches of mathematics was unquestioned.

On account, then, of the difficulties of the subject and of the profound importance of results which can be reached by no other known method, it is of the utmost consequence that the principles and processes of statistical mechanics should be put upon a firm

and certain foundation. That this has now been accomplished there can be no doubt, and there will be little excuse in the future for a repetition of the errors of which Maxwell speaks; moreover, theorems have been discovered and processes devised which will render easier the task of every future student of this subject, as the work of Lagrange did in the case of ordinary mechanics.

The greater part of the book is taken up with this general development of the subject without special reference to the problems of rational thermodynamics. At the end of the twelfth chapter the author has in his hands a far more perfect weapon for attacking such problems than any previous investigator has possessed, and its triumphant use in the last three chapters shows that such purely mechanical systems as he has been considering will exhibit, to human perception, properties in all respects analogous to those which we actually meet with in thermodynamics. No one can understandingly read the thirteenth chapter without the keenest delight, as one after another of the familiar formulæ of thermodynamics appears almost spontaneously, as it seems, from the consideration of purely mechanical systems. But it is characteristic of the author that he should be more impressed with the limitations and imperfections of his work than with its successes; and he is careful to say (p. 166): "But it should be distinctly stated that, if the results obtained when the numbers of degrees of freedom are enormous coincide sensibly with the general laws of thermodynamics, however interesting and significant this coincidence may be, we are still far from having explained the phenomena of nature with respect to these laws. For, as compared with the case of nature, the systems which we have considered are of an ideal simplicity. Although our only assumption is that we are considering conservative systems of a finite number of degrees of freedom, it would seem that this is assuming far too much, so far as the bodies of nature are concerned. The phenomena of radiant heat, which certainly should not be neglected in any complete system of thermodynamics, and the electrical phenomena associated with the combination of atoms, seem to show that the hypothesis of a finite number of degrees of freedom is inadequate for the explanation of the properties of bodies." While this is undoubtedly true, it should also be remembered that, in no department of physics, have the phenomena of nature been explained with the completeness that is here indicated as desirable. In the theories of electricity, of light, even in mechanics itself, only certain phenomena are considered which really never occur alone. In the present state of knowledge, such partial explanations are the best that can be got, and, in addition, the problem of rational thermodynamics has, historically, always been regarded in this way. In a matter of such difficulty no positive statement should be made, but it is

the firm belief of the present writer that the problem, as it has always been understood, has been successfully solved in this work; and if this belief is correct, one of the great deficiencies in the scientific record of the nineteenth century has been supplied in the first year of the twentieth.

In method and results, this part of the work is more general than any preceding treatment of the subject; it is in no sense a treatise on the kinetic theory of gases, and the results obtained are not the properties of any one form of matter, but the general equations of thermodynamics which belong to all forms alike. This corresponds to the generality of the hypotheses in which nothing is assumed as to the mechanical nature of the systems considered, except that they are mechanical and obey Lagrange's or Hamilton's equations. In this respect it may be considered to have done for thermodynamics what Maxwell's treatise did for electromagnetism, and we may say (as Poincaré has said of Maxwell) that Gibbs has not sought to give a mechanical explanation of heat, but has limited his task to demonstrating that such an explanation is possible. And this achievement forms a fitting culmination of his life's work.

Although the foregoing review demonstrates a vast amount of work, one must not conclude that it is an exhaustive catalogue of Professor Gibbs's activities. He is known to have made two interesting inventions in applied mechanics—one a brake for railway cars, which was patented,* and another, a type of governor of a higher order of approximation to astaticism than any of its predecessors, which was constructed in the machine shop of the Sheffield Scientific School and constitutes a valued apparatus in the collection of the Department of Physics. These incidents are quite sufficient to demonstrate that the inventor possessed all the mental qualifications necessary for a successful experimenter, and to render one curious as to why none of his published works includes any deductions founded upon experimental investigations of his own. Doubtless the reason is to be found in the fact that he was living in a period of intense activity in experimental research and record, so that he found abundant material already at hand to supply the quantitative data upon which he based his philosophical deductions. When this was wanting, however, no one in the circle of his intimates could doubt his capacity for supplying a deficiency by his own efforts. When

*U. S. Patent, No. 53971, April 17, 1866.

he was engaged upon his recondite analysis of the elastic theories of light he found what looked like a possible way of eluding the very great difficulties which come from the apparent non-existence of the compressural wave system; the tentative explanation, however, involved the occurrence of certain phenomena in specular reflection which had never been seen or, at least, recorded. As it did not seem to him that such negative evidence was conclusive, he constructed an apparatus with his own hands so perfectly adapted to the end in view that his observations afforded the proof sought. A striking light is thrown upon the character of the great physicist by the fact that no reference to this theory, which must have cost much critical study, appears in his writings, nor is it known that any one except the present writer ever saw the apparatus and made the experiment for which it was designed. Its only lasting effect was to add to the conviction, not at that time invincible, that the electromagnetic nature of light must be accepted as a verity.

As a member of the faculty of Yale University, Professor Gibbs constantly exhibited his interest in his work as an educator and manifested a reasonableness in his opinions no less striking than their occasional originality. With a perfectly courteous attitude toward those who differed from him, he never hesitated to express his views with extraordinarily clear logic and admirable diction. The severest criticisms of his colleagues were that his views were so broad, his opinions concerning important questions so carefully thought out and so judicial, that he often lacked the essential qualities of an advocate. His preferences in a proposed course of action were always obvious; but he could never blind himself to the advantages of a different course, and he seemed impelled to argue the affair as candidly with his associates as he did with himself. To one who knew his intellectual methods in pursuing a truth in the domain of physics, it was beautifully obvious that he did regard the administrative labors of a college faculty as a department of the exact sciences. When it became his duty to express an opinion on the merits of a candidate for higher academic honors, he was always kindly; he seemed as incapable of entertaining a very severe judgment of the intellectual deficiencies of a student as he was of holding his own achievements too highly. Fortunately, in his later life, at least, he had

little to do with the inevitable disciplinary work of the college; but had he been called upon, we are sure that his tendency would always have been to err, if at all, upon the side of clemency.

It will surprise no reader of the numerous biographical notes concerning Professor Gibbs to learn that a man of so judicial a temperament was a very successful man of affairs. Happily for science, his position in the University was not such as to render that fact conspicuous, else he might have been called upon for work which, in view of his consciousness and inherent modesty, could easily have seriously interfered with his scientific pursuits. He did, however, give his services as a trustee to the affairs of the Hopkins Grammar School of New Haven, and he acted for many years as treasurer of its funds, which had come down in part from colonial times.

Nothing is more difficult in a biographical memoir than to give to the reader a definite impression of the personal characteristics of an eminent man, of those characteristics which make the man in the eyes of such of his contemporaries as are unable to estimate him by his works. On the other hand, there is no more legitimate curiosity than that which prompts us to seek such information about a man who has impressed himself upon his times by his essential greatness. In many cases a mere accumulation of incidents in the life of one who has numerous points of contact with his fellow-men is all that is necessary for a discerning reader; but with one whose activities are chiefly intellectual this is often difficult, and particularly so with Professor Gibbs, who seems never to have sought or desired a wide circle of acquaintances. But we should greatly err if we concluded from this that Mr. Gibbs was of an unsocial nature. To me he always appeared quite the opposite—perfectly friendly and approachable, ready to talk on any subject, and always equable, he exhibited a flattering welcome to every friend. Effusiveness was as foreign to his nature as insincerity, but cordiality was never wanting. He laughed readily and possessed a lively sense of humor. Though rarely speaking of himself, he occasionally borrowed an example or an illustration from his personal experiences. One may be recorded here, not only because of his enjoyment of its humor, but because his great papers on thermodynamics, which have brought him undying fame, were first pub-

lished by the scientific society which received the curious criticism. A professor at the University of Berlin expressed to Mr. Gibbs, when he was there in 1868 attending various lecture courses, an interest in the Connecticut Academy of Arts and Sciences at New Haven. Mr. Gibbs gave the information demanded and casually stated that he himself was a member. This prompted the German scientist to the remark that "its memberships appear to be pretty freely bestowed." In the minds of students of recent history of science this story must awaken singular reflections, of which the humorous aspects would, perhaps, not be the most enduring. Still, although keenly alive to the pleasures of social intercourse, no one ever lived who was less dependent upon it. He seemed to have absolutely boundless resources within his own mind which would meet every want, whether for work or for pastime, and it was inevitable that such an exalted intellect should live much alone.

No qualities of Professor Gibbs impressed his sympathetic associates and his pupils more than his serenity and apparent unconsciousness of his intellectual eminence. Thoroughly characteristic and delightful is the remark which he once made to an intimate friend concerning his abilities as a mathematician. He said, with perfect simplicity and candor, "If I have had any success in mathematical physics, it is, I think, because I have been able to dodge mathematical difficulties."

Josiah Willard Gibbs was a member of a family which had long been distinguished for its scholars. He was descended from Robert Gibbs, the fourth son of Sir Henry Gibbs, of Honington, Warwickshire, who came to Boston about 1658. One of Robert Gibbs's grandsons, Henry Gibbs, in 1747 married Katherine, daughter of the Hon. Josiah Willard, secretary of the Province of Massachusetts. Of the descendants of this couple, in various parts of the country, no fewer than six have borne the name Josiah Willard Gibbs. On his father's side we find an unbroken line of six college graduates. Five of these were graduates of Harvard—President Samuel Willard, his son Josiah Willard, the great-grandfather, grandfather, and father of the elder Professor Gibbs, who was himself a graduate of Yale. Among his mother's ancestors were two more Yale graduates, one of whom, Rev. Jonathan Dickinson, was the first president of the College of New Jersey.

Many learned societies and universities have conferred their honors upon Professor Gibbs in recognition of his great services to science. The list of academies and societies of which he was a member includes the Connecticut Academy of Arts and Sciences, the National Academy of Sciences, the American Philosophical Society, the Dutch Society of Sciences, Haarlem; the Royal Society of Sciences, Göttingen; the Royal Institution of Great Britain, the Cambridge Philosophical Society, the London Mathematical Society, the Manchester Literary and Philosophical Society, the Royal Academy of Amsterdam, the Royal Society of London, the Royal Prussian Academy of Berlin, the French Institute, the Physical Society of London, and the Bavarian Academy of Sciences. He was the recipient of honorary degrees from Williams College, and from the universities of Erlangen, Princeton, and Christiania. In 1881 he received the Rumford Medal from the American Academy of Boston, and in 1901 the Copley Medal from the Royal Society of London

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Elliott Coues.

NATIONAL ACADEMY OF SCIENCES
BIOGRAPHICAL MEMOIRS
PART OF VOLUME VI

BIOGRAPHICAL MEMOIR

OF

ELLIOTT COUES

1842-1899

BY

J. A. ALLEN

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL, 1909

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
June, 1909

NATIONAL ACADEMY OF SCIENCES.

Of the biographical memoirs which are to be included in Volume VI, the following have already been issued:

WASHINGTON, D. C.
JUDD & DETWEILER, INC., PRINTERS.
1909.

BIOGRAPHICAL MEMOIR OF ELLIOTT COUES.

ELLIOTT COUES* was born in the town of Portsmouth, New Hampshire, September 9, 1842, and died in the Johns Hopkins Hospital, in Baltimore, Maryland, December 25, 1899, at the age of 57 years, the immediate cause of death being a grave surgical operation for an affection of the throat. He was a son of Samuel Elliott and Charlotte (Haven) Coues.

Dr. Coues† came of excellent New England ancestry. The first of the Coues line to settle in America was Peter Coues, great-grandfather of Elliott Coues, who was born in the Parish of Saint Peters, Island of Jersey, Channel Islands, and came to Portsmouth, New Hampshire, about 1735, where he was married November 4 of the same year, and where he died at an advanced age, about 1783. His son, grandfather of the subject of this memoir, was Captain Peter Coues, born in Portsmouth, New Hampshire, July 30, 1736, where he died November 29, 1818, at the age of eighty-two years. In early life he was a sea captain, and for a time an officer in the British Navy, but he returned to Portsmouth some time before the beginning of the American Revolution. Here he spent the remainder of his life, becoming a prominent citizen and one of the founders of the Universalist Church of Portsmouth. It is a family tradition that he was at one time sailing master of the famous *Royal George*, which capsized and sank in the roadstead at Spithead, England, in August, 1782. A number of Captain Coues's relatives were also officers in the British Navy.

Dr. Coues's father, Samuel Elliott Coues, was born in Portsmouth, New Hampshire, June 13, 1797, and died there July 3, 1867. In early life he was a merchant, but later, for many

* Pronounced *Kouz*. Cf. the Century Cyclopedia of Names, 1894, p. 285.

† I am greatly indebted to Mr. Joseph Foster, of Portsmouth, N. H., for a very full genealogical history of Coues's ancestry, on which the following brief summary is wholly based.

years, held an appointment in the Patent Office at Washington, where he resided from 1853 to 1866. He was a man of literary tastes, active in humanitarian movements, and for several years was president of the American Peace Society. He was the author of "Mechanical Philosophy" (Boston, 1851) and "Studies of the Earth," etc. (Washington, 1860). It is said of him that he had "a keen perception of the beauties and mysteries of nature and an ever-pervading feeling of philanthropy."

Dr. Coues's ancestry on his mother's side is traced back, on different lines, to John Mason (d. 1635), the original grantee of New Hampshire, to the Appletons and Havens of Massachusetts, and to other distinguished New England families (among them to Governor Thomas Dudley). Charlotte Haven (Ladd) Coues, Dr. Coues's mother, was a direct descendant from Daniel Ladd, who came to New England in 1633-1634, and, after short residences at Ipswich and Salisbury, became one of the original settlers of Haverhill, Massachusetts, where he died in 1693. Coues's mother survived him by a few months, dying at Brookline, Massachusetts, July 4, 1900.

Coues's grandmother, wife of Captain Peter Coues, was Rebecca Elliott, a daughter of Samuel Elliott, who came from Topsham, Devonshire, England, and was married at Portsmouth, New Hampshire, May 6, 1761. This connection is the source of the baptismal name Elliott in the later generations of the Coues family.

It thus appears that Dr. Coues's ancestry was partly French and partly English. His forebears on the English side in America were among the earliest settlers of New England, and belonged to families of distinction, there being among them a former president (Haven, 1749-1806) of Harvard College. It also appears that his immediate predecessors for several generations were all residents of Portsmouth, New Hampshire.

As already noted, Dr. Coues's father removed with his family from Portsmouth to Washington in 1853, when Elliott was eleven years old, and this city became the future residence of the younger Coues until his death, except when away on official duties during his nearly twenty years' service in the medical corps of the United States Army. He prepared for college at Gonzaga Seminary, a Jesuit school in Washington, and later

entered Columbian College of that city (afterwards called Columbian University and now known as George Washington University), from which he received the degree of A. B. in 1861 and M. D. from its medical department in 1863. From the same institution he received the honorary degree of A. M. in 1862 and that of Ph. D. in 1869. Here for ten years—1877-1886—he acceptably filled the chair of anatomy.

In 1869 he was chosen to the chair of zoölogy and comparative anatomy at Norwich University, Vermont, which position, however, he was unable to accept.

His military career began in 1862, when he enlisted in the United States Army as a medical cadet; he was promoted to acting assistant surgeon in 1863, and to assistant surgeon in 1864, serving in this capacity till 1881, when he resigned from the army to devote his entire time to scientific and literary pursuits. He was assigned to his first military post at Port Whipple, Arizona, in March, 1864,* where he remained for sixteen months, making the journey from Fort Leavenworth to Santa Fé, New Mexico, by mail coach, and thence to Fort Whipple on horseback, traveling with the military command to which he was officially attached. During his assignment to Fort Whipple he made a military journey from Fort Whipple to San Pedro, on the coast of southern California, via Fort Mojave and Fort Yuma.† Later his travels in the service of the Government gave him an opportunity to become personally familiar with the physical features of other portions of the West while it was still unchanged by the inroads of civilization. On his return from Fort Whipple he was assigned to Fort Macon, North Carolina,

* For an interesting sketch, with portrait, of Dr. Coues at this enthusiastic stage of his ornithological career, see a paper by Captain C. A. Curtis, U. S. A. (retired), entitled "Coues at his first Army Post," published in "Bird-Lore" in 1902 (Vol. IV, pp. 5-7), together with an extract from Coues's Journal, referring to a day's march in New Mexico (reprinted from the "American Naturalist," Vol. V, June, 1871, pp. 199, 200).

† The ornithological results of his journey from Fort Leavenworth to Fort Whipple and from Fort Whipple to the Pacific coast are given in two papers published in "The Ibis," entitled respectively "Ornithology of a Prairie Journey" (Ibis, April, 1865, pp. 157-165) and "From Arizona to the Pacific" (Ibis, July, 1866, pp. 259-265).

and afterwards to Fort McHenry, Baltimore, Maryland. In 1873 he was ordered to Fort Randall, Dakota, and thence assigned (1873-1876) as surgeon and naturalist to the United States Northern Boundary Commission. From 1876 to 1880 he was detailed as secretary and naturalist to the United States Geological and Geographical Survey of the Territories, under the late Dr. F. V. Hayden. In 1880 he was again ordered to Arizona, but the surroundings of a post surgeon on the frontier were so incompatible with the prosecution of the scientific work he had then in hand that, failing to receive a more favorable assignment, he resigned his commission and returned to Washington.

Dr. Coues early showed a strong liking for natural history pursuits, and especially for ornithology, to which he later became passionately devoted. His residence in Washington, with free access to the collections of the Smithsonian Institution and intimate association with the late Professor Baird and other leading naturalists connected with this great institution, afforded him the incentive and opportunities for research which he early and enthusiastically embraced. His first technical paper was "A Monograph of the Tringeæ of North America," published in the Proceedings of the Academy of Natural Sciences of Philadelphia in July, 1861 (pp. 170-205), when he was only nineteen years old. This paper was notable for the care and completeness with which the subject was treated, and would have been creditable to an author of much greater experience. It fully foreshadowed the high character of his subsequent work in systematic ornithology.

This paper was followed in the same year by his "Notes on the Ornithology of Labrador,"* based on field observations and collections made by him on a visit to that country in 1860. This was succeeded the same year by "A Monograph of the Genus Ægiothus, with Descriptions of new Species,"† and the following year by a faunistic paper (with D. Webster Prentiss) on the birds of the District of Columbia,‡ and the beginning of a series

* Proc. Acad. Nat. Sci. Philadelphia, 1861, pp. 215-257.

† *Ibid.*, pp. 373-390.

‡ Sixteenth Ann. Rept. Smithsonian Institution for 1861 (1862), pp. 399-421.

of monographs (1862-1868) on various groups of water birds, as follows: "Synopsis of the North American Forms of the Colymbidæ and Podicipidæ";* "Revision of the Gulls of North America";† "A Review of the Terns of North America";‡ "Critical Review of the Family Procellariidæ,"§ and "A Monograph of the Alcidæ."‖ Here may also be mentioned his "Classification of Water Birds";¶ his "Studies of the Tyrannidæ, Part 1. Revision of the Species of Myiarchus";** and his "Material for a Monograph of the Spheniscidæ."†† During this same decade he also published several papers on the anatomy of birds.‡‡

Dr. Coues's writings cover the whole field of ornithology, and, including reviews and short notes on special subjects, number probably more than five hundred titles, but, with the exception of a few revisionary, monographic, and bibliographical papers, deal almost exclusively with the birds of North America north of Mexico. His greatest service to ornithology is, beyond question, his "Key to North American Birds," the first edition of which appeared in 1872 and the fifth and last in 1903, four years after the author's death. This edition was in reality, as respects the general text, the third revised edition, the third and fourth editions being reprints of the second, with the addition of important appendices.

The "Key" was designed as a popular handbook of North

* Proc. Acad. Nat. Sci. Philadelphia, Vol. XIV, 1862, pp. 226-233.

† *Ibid.*, pp. 291-312—an abstract of a monograph published in full twelve years later in "Birds of the Northwest," 1874, pp. 589-717.

‡ *Ibid.*, pp. 535-559.

§ *Ibid.*, Vol. XVI, 1864, pp. 72-91, 116-144; Vol. XVIII, 1866, pp. 25-33, 134-197.

‖ *Ibid.*, Vol. XX, 1868, pp. 2-81, figs. 1-16.

¶ *Ibid.*, Vol. XXI, 1869, pp. 193-218.

** *Ibid.*, Vol. XXIV, 1872, pp. 56-81.

†† *Ibid.*, pp. 170-212, pls. iv, v.

‡‡ "The Osteology of the *Colymbus torquatus;* with Notes on its Myology." Mem. Boston Soc. Nat. Hist., Vol. I, pt. ii, 1866, pp. 131-172, pl. v, and 2 text figures.

Bird's-Eye Views [on the structure of the eye in birds]. American Naturalist, Vol. II, 1868-69, pp. 505-513, 571-583, with illustrations.

Mechanism of Flexion and Extension in Birds' Wings. Proc. American Assoc. Adv. Sci., Vol. XX, 1871 (1872), pp. 278-284, with illustrations.

American birds, and was one of the first works to introduce the "key" method of botanical manuals into zoölogy. It was at the same time a taxonomic revision of North American birds from the standpoint of a competent authority.

The first edition of the "Key" contained an "Introduction" of some sixty pages, giving a general account of the external characters of birds, an explanation of the technical terms used in ornithology, a concise exposition of the principles of classification and nomenclature, an artificial key to the genera, and much other information useful to the amateur. A systematic synopsis of North American birds followed, with brief descriptions of the species, indications of their geographical distribution, and references to leading authorities. By skillful use of language and several hundred illustrations, the amount of text was reduced to small compass without serious sacrifice of clearness. The higher groups were quite fully characterized, and a synopsis of fossil North American birds was added. Many changes in classification were introduced, and many "species" were reduced to "varieties," this being before the days of trinomial nomenclature.

The second edition (1884) was prepared on essentially the same lines, but it was entirely rewritten and greatly augmented, containing twice the number of pages and, through use of smaller type, nearly four times the amount of matter, and a large increase in the number of illustrations.

The "Key" now comprised four "Parts," namely: Part I, "Field Ornithology," a reprint, with slight modifications, of a separate work issued by the author under this title in 1871. Part II, "General Ornithology," consisting of the introductory matter of the first edition, greatly amplified, with the further addition of nearly one hundred pages of new matter on the anatomy of birds. Part III, "Systematic Synopsis of North American Birds," is the "Systematic Synopsis" of the first edition, greatly extended by fuller diagnoses and the addition of concise biographies of the species. Part IV, is the "Systematic Synopsis of the fossil Birds" brought down to date and the subject more fully presented. The nomenclature is materially changed throughout, some twenty or more groups previously rated by him as subgenera being here given full generic rank, entailing corresponding changes in the names of species.

The four parts are preceded by an "Historical Preface" of twenty pages of wholly new matter, which is a concise history of North American ornithology, from its earliest beginnings in 1612 to the year 1860. The history is divided into epochs and periods, and the work and impress of each prominent author is briefly and judicially weighed, with the author's usual felicity of characterization.

The third edition (1887) is the same as the second, with the addition of an appendix of thirty pages, "exhibiting the nomenclature of the American Ornithologists' Union Check-List in comparison with that of the Key and including descriptions of additional species, etc.," the American Ornithologists' Union Check-List of North American Birds having appeared during the interval between the second and third editions of the "Key." The names employed in the two systems are arranged in parallel columns, with the interpolation of descriptions of some sixty species and subspecies not previously included in the "Key."

The fourth edition (1890) is the same as the third, with the addition of a second appendix, to include a number of further additions of species and subspecies.

The fifth edition (1903), issued in two volumes instead of one, is again largely a new work, the synoptic portion having been wholly rewritten and greatly enlarged, the classification and arrangement considerably altered, and the nomenclature revolutionized. This being the first revised edition of the "Key" since the appearance of the American Ornithologists' Union Check-List in 1885, we have here the nomenclature of this list, which Dr. Coues did so much to shape, for the first time adopted in the "Key," the author often waiving his own opinions and preferences for the sake of conformity with the Check-List. Many of the old illustrations were discarded and hundreds of new ones added, made expressly for the work. The "Historical Preface," the "Field Ornithology," and the "General Ornithology" are the same as in former editions, except that in the latter, besides slight verbal changes in the text, much new matter is added. The changes in Part III, besides those of nomenclature and arrangement, consist in the amplification of many of the diagnoses, a revision of the ranges of the species and subspecies, the addition of bibliographical references, many vernacular synonyms,

and much critical and historical comment on questions of nomenclature (almost wholly excluded in former editions); also the characterizations of the higher groups are more elaborate and extended, their composition and relations being stated with masterly clearness and comprehensiveness. As stated by the present writer in a review of the "New Key," it is a "masterpiece of mature ornithological work, which alone would long keep green the memory of its gifted author." The "Key" is a "well-known and old favorite, whose thirty years of practical usefulness have won for it unstinted and well-merited praise, and in its new form will prove for many years to come a boon alike to the amateur and the professional student of North American birds. The 'Key' of 1872 was an innovation and an experiment in ornithological literature; its practicability was evident from the outset, and it proved to be the forerunner of almost numberless successors of 'key' manuals in various departments of zoölogy. The author's final revision of this greatest of his many contributions to ornithological literature will make a new generation of bird students his debtors and admirers."* It was his last piece of literary work, and could he have lived to carry it through the press its publication would have been not only less delayed, but the work would have had the benefit of his final touches.

The "Key" was recognized, abroad as well as at home, as a work of the highest excellence. In a review of the second edition in "The Ibis" (1885, pp. 100, 101), a journal not noted for its use of superlatives in its notices of current literature, the following high praise is accorded the "Key":

"It is, however, to Part II of the present volume that we must specially direct the reader's attention. In this Part there is condensed into some 180 pages a more complete account of the structure and classification of birds, brought up to the present standard of our knowledge, than any other with which we are acquainted. * * * So much information that cannot be got at elsewhere is brought together in this comprehensive treatise, that it ought to be in the hands of every ornithologist, whether he is a special student of the American avifauna or not. It is, in fact, our deliberate opinion that Coues's new 'Key' is, as one of the veteran ornithologists of the continent has tersely put it, in a private letter, 'one of the best and most useful bird books ever written;' and we commend it to our readers accordingly."

* Auk, Vol. XXI, 1904, p. 296.

Closely conjoined with the "Key to North American Birds" are three other publications by Dr. Coues, namely, a "Check-List of North American Birds," his "Field Ornithology," and a second edition of his Check-List, entitled "The Coues Check-List of North American Birds, Second Edition."

The first edition of the Check-List was published in December, 1873, forming a brochure of 137 pages, and a bare catalogue of scientific and vernacular names, printed in thick type on one side of the paper, with critical comment in footnotes and in a 15-page appendix. It was reissued in January, 1874, with the "Field Ornithology." The Check-List was "prepared in strict accordance with the Key" and "reflects exactly whatever of truth or error that work represents." As said by the author, the need of a new check-list was urgent, the first and only previous check-list of North American birds being that of Baird, published in 1858. In the meantime great changes had been made, through the addition of some fifty species, the removal of many as extra-limital or invalid, and the reduction of a large number of others to the rank of "varieties." In the introduction to the combined "Manual of Instruction and Check-List of North American Birds," the author says:

"In the present state of our knowledge, and under a system of nomenclature that is proven inadequate and may before long become obsolete, recognition of numerous 'varieties'—resultant modifications of species by physical conditions of environment—is imperative; and what are these varieties but the rills that flow into and help swell the mighty stream of descent with modification?"

Here was reflected the tendency, already prevailing among the leading American ornithologists of that time, to reduce the status of local forms from species to "varieties" (later called "subspecies"), such a reduction being for the first time consistently made for the whole ornis in the first edition of the "Key."

The "Field Ornithology" and "Check-List" were intended originally to form part of the first edition of the "Key," with which the "Field Ornithology" was combined in all of the later editions of that work. The scope and purpose of the "Field Ornithology" is well indicated by the subtitle, "A Manual of Instruction for procuring, preparing, and preserving Birds." It

was divided into eight chapters, covering such subjects as collecting implements and their use, directions and suggestions for field work, the registration and labeling of specimens, the preparation of birdskins, determination of sex, etc., and the care of collections.

The instructions here offered were based on the author's many years of field experience, and were not only detailed and judicious, but were presented with a familiarity and charm of style that made even such dry details attractive. It is thus, without doubt, one of the most useful and popular manuals of ornithological field work ever put forth.

The second edition of the "Coues Check-List" appeared in 1882, a royal octavo of 165 pages, containing as an appendix a "Catalogue of the Author's Ornithological Publications, 1861-1881," numbering 300 titles. The second edition is a very different work from the first, inasmuch as it is philological as well as ornithological. In nomenclature and classification the second Check-List is a faithful reflection of the second edition of the "Key," and holds to it the same relation that the first Check-List held to the first edition of the "Key." Furthermore, it was the nomenclature followed in all subsequent editions of the "Key" down to and including the fourth, published in 1887, with a few additions and slight changes in the appendices to the third and fourth editions.

Baird's Check-List, published in 1858, included 722 species and subspecies (excluding 22 recognized by Baird himself as extralimital); the first Coues Check-List (1872) included (with the 28 given in the appendix) 778, an increase of 66 over the Baird list; the second Coues Check-List (1882) included 888, an increase of 100 over the Coues list of 1872.

A Check-List of North American birds was also published by Ridgway in 1880.* This comprised 924 species and subspecies, of which 37 were admitted by the author to be extralimital, leaving as "North American" 887, or one less than the number recognized by Coues. The two lists are, however, very unlike, not

* "A Catalogue of the Birds of North America." By Robert Ridgway. Proc. U. S. Nat. Mus., Vol. III, 1880, pp. 163-246. Also separate, as: "Nomenclature of North American Birds," forming "Bulletin of the United States National Museum, No. 21," pp. 1-94, 1881.

only as regards nomenclature, but in the species and subspecies (especially the latter) admitted or excluded by the two authors. This comparison of check-lists connotes in a general way the advance of knowledge of the forms of the North American ornis for the twenty-four years between 1858 and 1882, which may be taken also as an indication of the general advance made in our knowledge of the geographical distribution and life histories of the birds of North America north of Mexico.

To revert now to the second Coues Check-List: According to the author, the changes in nomenclature from his first list are numerous and in many instances radical, affecting not less than 150 cases, while the changes in ornithological status are "probably not more than 30." Respecting this edition of the Check-List he says:

"In revising the list for the main purpose of determining the ornithological *status* of every North American bird, the most scrupulous attention has been paid to the matter of nomenclature, not only as a part of scientific classification, determining the technical relations of genera, species, and varieties to each other, but also involved in writing and speaking the names of birds correctly. The more this matter was scrutinized, the more evidences of inconsistency, negligence, or ignorance was discovered in our habitual use of names. It was therefore determined to submit the current catalogue of North American birds to a rigid examination, with reference to the spelling, pronunciation, and derivation of every name—in short, to revise the list from a philological as well as an ornithological standpoint."

Accordingly some twelve pages are devoted to the philological phase of the subject, which is discussed under the several heads of etymology, orthography, and orthoepy. After explanations of the English, Continental, and Roman methods of pronunciation, he adopts the latter to the extent of insisting upon "the Roman sounds of the vowels and diphthongs, but yields the point in the disputed cases of certain consonants."

More than half of the space of the Check-List is occupied by the etymology, pronunciation, and definition of the technical names—an instructive and important feature, almost unique in such a connection; but neither his emendations of names, nor his prescribed Roman pronunciations made much impress upon the users of the Check-List. Indeed, in less than four short years

the American Ornithologists' Union, through a committee of which he was chairman, adopted and published, in the interest of stability in nomenclature, a rule that "the original orthography of a name is to be rigidly preserved, unless a typographical error is evident," and a check-list of North American birds in which this rule was strictly enforced. Yet Dr. Coues, in all the subsequent editions of his "Key" and in his other works, continued to employ his own "corrected"[2] names; but he did not use in private conversation nor in scientific discussion the Roman method of pronunciation, nor did he introduce it into any edition of the "Key."

Although he was loyal (except in the spelling of names) to the American Ornithologists' Union "Code of Nomenclature" and to the American Ornithologists' Union Check-List, which on its appearance in 1886 immediately supplanted all previous check-lists of North American birds, he properly reserved the right of individual judgment in all questions of ornithological science. Thus, in the preface to the third edition of the "Key" (1887) he says:

> "Uniformity of nomenclature is so obvious and decided a practical convenience that even at the risk of seeming to laud work in which he had a hand, the author cannot too strongly urge compliance with the Union's code, and adherence to the set of names the Union has adopted. These may not be the best possible, but they are the best we have."

In the "Appendix" to this edition of the "Key," as already noted, he gave the nomenclature of the "Key" and the American Ornithologists' Union Check-List in parallel columns, which made the occasion for any display of dissent or criticism of that work he may have felt, yet this "consists chiefly in declining to admit to the 'Key' some forms that the American Ornithologists' Union committee have deemed worthy of recognition by name." The number of forms he saw fit at this time to exclude is not large, and nearly all were admitted by him in his later (fifth) edition of the "Key." Yet his adhesion to purism in the construction of names, despite the American Ornithologists' Union and other codes of nomenclature to the contrary, continued to the end and proved in later years the cause of estrangement be-

tween himself and some of his (otherwise and formerly) most esteemed colleagues.

In his first check-list, Coues protested against the use of "so many needless and burdensome generic names, * * * adopted in Baird's great work," which he discarded in the first edition of the "Key," but gradually adopted in the later editions, with others proposed in the meantime by himself and others, in accordance with the prevailing custom of recent authorities.

Other important ornithological works by Dr. Coues are his "Birds of the Northwest," published in 1874, and his "Birds of the Colorado Valley," published in 1878, both in the "Miscellaneous Publications" series of the Hayden Geological Survey The first of these, the "Birds of the Northwest: A Hand-book of the Ornithology of the Region drained by the Missouri River and its Tributaries" (8vo, pp. xii+791) treats primarily of the birds of the Missouri region (about 450 species), with reference to their geographical distribution, habits, and synonymy, and the specimens taken on various expeditions under the late Dr. F. V. Hayden; the North American species of the families Laridæ, Colymbidæ (=Gaviidæ), and Podicipidæ (=Colymbidæ), however, being, in addition, treated monographically, abstracts of which monographs were published in 1862-1863. Two new genera and one new species are here described, and there are various rectifications of nomenclature. The work is an important summary of the ornithology of the region treated, as then known, and will ever remain a standard work of reference.

Here may also be mentioned a fourth important contribution to the ornithology of a portion of this general region, namely, his "Field Notes on Birds observed in Dakota and Montana along the Forty-ninth Parallel during the seasons of 1873 and 1874,"* embodying the results of his ornithological field work as naturalist to the United States Northern Boundary Commission. The line surveyed extended from the Red River of the North to the Rock Mountains, a distance of about 850 miles. The faunal characteristics of different portions of the route are compared, followed by a systematic list of the species observed, with the

* Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. IV, No. 3, July 29, 1878, pp. 545-661.

localities, dates, and measurements of the specimens taken, and extended biographical notes on many of the species, some of which were previously little known, resulting altogether in a large amount of wholly new information about the birds of this region.

The publication of the "Birds of the Colorado Valley" (8vo, pp. xvi+807, figs. 70), in 1878, was a marked event in the literature of North American ornithology and added immensely to the reputation of this already well-known and extremely popular author. The subtitle of the work, "A Repository of Scientific Information concerning North American Ornithology," is fully justified by its contents, and it has ever been sincerely regretted, by ornithological amateurs and experts alike, that the "Part First, Passeres to Laniidæ," with the "Bibliographical Appendix," is the only portion of the work ever published. It is not too much to say that this volume will ever remain a classic in ornithological literature. The biographical portions display to the fullest Coues's wonderful command of the English language, and prove, as claimed in the "Prefatory Note" (p. vi):

"It is possible to make natural history entertaining and attractive as well as instructive, with no loss in scientific precision, but with great gain in stimulating, strengthening, and confirming the wholesome influence which the study of the natural sciences may exert upon the higher grades of mental culture; nor is it a matter of little moment to so shape the knowledge which results from the naturalist's labors that its increase may be susceptible of the widest possible diffusion."

At the same time, the technical portions of the work measure up to the highest standards, and the bibliographical appendix established a grade of efficiency never before attained, and set a model for the emulation of all future natural history bibliographers.

This work is a systematic treatise on the birds of the region drained by the Colorado River (embracing all of Arizona, much of New Mexico, Utah and Nevada, and portions of Colorado and southern California), with the synonymy and bibliography (mostly in footnotes) of the extralimital North American species of the families treated. The higher groups are fully characterized, and their relationships elaborately discussed, as nearly as possible

in non-technical phraseology; full descriptions are given of the external characters of the species, with exhaustive tables of synonymy and bibliographic references, a brief statement of the ranges of the species and "varieties," and usually extended biographies, some of them remarkable for their literary excellence, the common-place facts of bird-dom being often infused with a flavoring of poetic imagery. Chapter XIV, on the Swallows (Hirundinidæ), is ideal in its combination of technical details with general information, arranged under sections entitled: "Names of Swallows," "General Distribution of Swallows," "Migration of Swallows," "Architecture of Swallows," "Abnormal coloration of Swallows," and "General Habits and Traits of Swallows," followed by detailed treatment of the genera and species of this family found in North America, including very full biographies, presented with the felicity of touch characteristic of the author at his best. Under "Migration of Swallows" is a long dissertation on the question, Do swallows hibernate? which includes, besides a summary of the alleged evidence, an exhaustive annotated bibliography of special articles on the subject, occupying a dozen pages and numbering nearly two hundred titles. He says, in commenting on the evidence:

"I have never seen anything of the sort, nor have I ever known one who had seen it; consequently, I know nothing of the case but what I have read about it. But I have no means of refuting the evidence, and consequently cannot refuse to recognize its validity. Nor have I aught to urge against it, beyond the degree of incredibility that attaches to highly exceptional and improbable allegations in general, and in particular the difficulty of understanding the alleged abruptness of the transition from activity to torpor. I cannot consider the evidence as inadmissible, and must admit that the alleged facts are as well attested, according to ordinary rules of evidence, as any in ornithology. It is useless as well as unscientific to pooh-pooh the notion. The asserted facts are nearly identical with the known cases of many reptiles and batrachians. They are strikingly like the known cases of many bats. They accord in general with the recognized conditions of hibernation in many mammals."

There are also special bibliographies* on the "Architecture of

* The titles here given in the body of the work are, unfortunately for the convenience of subsequent authors, not repeated in Coues's later published bibliographies.

Swallows" and on "Abnormal Coloration of Swallows"; and there is another special bibliography (117 titles) on the genus "*Ampelis*" (=*Bombycilla*), of the family "Ampelidæ" (= Bombycillidæ).

The last 217 pages of the main text of the "Birds of the Colorado Valley" form a "Bibliographical Appendix," entitled "A List of Faunal Publications relating to North American Ornithology." The list is made up mainly of titles of " 'local lists' and allied kinds of articles,' all general treatises including larger geographical areas than North America, although North America may be included, being excluded, as are also all systematic papers treating of genera or higher groups, even when consisting wholly of North American species, these latter, under the author's plan of a "Universal Bibliography of Ornithology," falling under the section "Systematic Ornithology." The geographical limits are North America from the southern boundary of Mexico northward, including Greenland, and also the Bahamas and Bermudas, but not the West Indies nor any part of America south of Mexico. The author says: "There is little to be said of the way in which the work has been done; for if it cannot speak for itself, the less said the better." He adds, however, that "the compiler has habitually regarded THE TITLE as a thing no more to be mutilated than a man's name; and that he has taken the utmost pains to secure transcription of titles *verbatim, literatim et punctuatim*"; and further states that "*no title * * * has been taken at second-hand,*" unless so specified. The list begins with John Smith's description of Virginia, published in 1612, and ends with papers and works that appeared during the first half of the year 1878. The list is followed by an index, arranged in two sections, the first of authors, the second of localities, the great utility of which is obvious.

Aside from the complete and exact transcription of titles, whether of independent works or of papers published in journals or in the proceedings of societies and academies, the extent and character of the information given in relation to North American ornithology is indicated by descriptive comment or concise annotations, as may be required, which add immensely to the usefulness of the citations. As said by the author:

"Bibliography is never finished, and always more or less defective, even on ground long gone over. * * * In fact, one object in printing the present batch of titles is to invite criticism, to the end that the final bibliography may be bettered. The writer would be accurate; yet he feels the weight of Stevens's satire: 'If you are troubled with a pride of accuracy, and would have it completely taken out of you, print a catalogue.' "

Coues's several instalments of his ornithological bibliography certainly do "speak for themselves." That there are omissions goes without saying, but they are surprisingly few; the accuracy and completeness of citation are beyond criticism, while the concise descriptions supply information of the utmost convenience.

The "Bibliographical Appendix" to the "Birds of the Colorado Valley" forms the first instalment of a proposed "Universal Bibliography of Ornithology," to which Dr. Coues devoted a large part of several of the most active years of his life, the greater part of which still remains in manuscript, greatly to the regret and distinct loss of ornithologists the world over. Fortunately, however, that relating to American ornithology was practically completed up to the time of its publication, 1878-1880. The second instalment* was published in 1879, and includes the faunal works and papers relating to South America, Central America, and the West Indies, and contains about 700 titles. It is constructed on the same lines and with the same care as that relating to North America, already described.

The third instalment†, published in 1880, also relates to America, and consists of titles referring to systematic ornithology, or to "publications treating of particular species, genera or families." This portion makes nearly five hundred and fifty pages, and completes the Bibliography so far as America is concerned.

Only one instalment relating to birds of other parts of the world was ever published, namely, "Fourth Instalment of

* "Second Instalment of American Ornithological Bibliography." Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. V, No. 2, September 6, 1879, pp. 239-330.

† "Third Instalment of American Ornithological Bibliography." Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. V, No. 4, September 30, 1880, pp. 521-1066.

Ornithological Bibliography: being a List of Faunal Publications relating to British Birds."* This consists of "the titles of all publications treating of British birds as such, exclusively, and indiscriminately or collectively," as further fully defined in the introductory explanations.

It is only fair to give here the author's own point of view respecting these several instalments of his proposed "Universal Bibliography of Ornithology." He says:

> "This instalment, like those that have preceded it, is to be considered only in the light of published proof-sheets, to be canceled on the final appearance of the whole work. They are thus published in advance for several reasons—among others, both to render available certain departments of the Bibliography which approach completion, and are therefore useful as far as they go, and to invite suggestions and criticism for the bettering of the work."

Of this instalment he further says: "I do not think it contains more than one-half as many titles as belong to this department of the Bibliography"; and he goes on to indicate certain sources of its weakness through his inability to lay hands on various desired serial and other publications.

In the introduction to the "Third Instalment" (which was published several months later than the fourth) he says:

> "The portions of the Bibliography now before the public suffice for an estimate of its plan and purpose; but I may add that nothing has yet appeared of several other important departments, such as those of 'General and Miscellaneous' publications, of publications in 'Anatomy and Physiology,' of publications relating to 'Birds in Domestication and Captivity,' etc. It is not my intention, however, to print any more of the work at present, the *American* departments being the only ones sufficiently perfected to warrant their leaving my hands. But meanwhile I am making manuscript for the rest as rapidly and as continuously as possible."

Alas that this vast amount of expert labor should still remain unavailable to the ornithological world!†

* Proc. U. S. Nat. Mus., Vol. II, May 31, 1880, pp. 359-482.

† His latest public reference to this phase of his literary work appeared in "The Osprey" for November, 1897 (II, pp. 39, 40), from

Dr. Coues was joint author or editor and annotator of various ornithological papers and special works, as papers on the ornithology of Texas by Lieut. C. A. H. McCauley (1877) and George B. Sennett (1877 and 1879), and on the ornithology of Kerguelen Island (with Dr. J. H. Kidder). Stearns's "New England Bird Life, a Manual of New England Ornithology," "edited from the manuscripts of Winfrid A. Stearns" (two volumes, 1881) was, as is well known, practically written by Coues. He also collaborated with Mrs. Mabel Osgood Wright in the preparation of "Citizen Bird" (1897). He was also one of the associate editors of the "Bulletin" of the Nuttall Ornithological Club (1876-1883) and of the earlier volumes of "The Auk" (1884-1888).

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which I transcribe the following extract, for the information it conveys, and as an excellent illustration of Couesian rhetoric:

"The bibliography of ornithology is a subject which occupied me for several years, in the seventies, and upon which I expended an enormous amount of labor, mainly with my own pen, with comparatively little ostensible result. In 1880 I had published four instalments of my intended 'Universal Bibliography of Ornithology,' these being a few thousand titles relating to the birds of North and South America and Great Britain. In that year my machinery for doing the work broke down, and I found myself amidst the debris of the great plan I had projected or partially accomplished, with many thousand manuscript titles on hand and no prospect of their ever seeing the light. * * * I think I never did anything else in my life which brought me such hearty praise 'in mouths of wisest censure'—immediate and almost universal recognition, at home and abroad, from ornithologists who knew that bibliography was a necessary nuisance and a horrible drudgery that no mere drudge could perform. It takes a sort of an inspired idiot to be a good bibliographer, and his inspiration is as dangerous a gift as the appetite of the gambler or dipsomaniac—it grows with what it feeds upon, and finally possesses its victim like any other invincible vice. Perhaps it is lucky for me that I was forcibly divorced from my bibliographical mania; at any rate, years have cured me of the habit, and I shall never again be spellbound in that way. * * * This raises another question, which may be put in this way: Where is the man who will undertake to bring my North American Bibliography up-to-date? * * * Among the requisite qualifications may be reckoned more zeal than discretion, youth, health, strength, staying power, unlimited time at command, and access to the foci of ornithological literature in some large eastern city. All my material, both published and unpublished, shall be at the service of any such individual, with such opportunities, and any such appetite for bibliographical immortality; I will even throw my blessing into the bargain. What do I hear in answer to this advertisement: Wanted—A competent bibliographer of North American ornithology?"

Coues's contributions to North American mammalogy, while somewhat voluminous, were far less important than his ornithological writings, and relate to a field with which he was far less familiar. His activities in this field were also limited to the decade between 1868 and 1877. His first papers on mammals appeared in 1867, and were based on his field notes and collections made in Arizona.* These were followed during the next ten years by notes and short articles on different North American species, by several anatomical papers,† by a faunal list of the mammals of Fort Macon, North Carolina‡, and by a number of systematic papers and monographs on various genera and families, chiefly during the years 1874 to 1877. The first was entitled "On the Muridæ of the Northern Boundary Survey, with critical revision of the North American Genera and Species,"§ an abstract of his monograph of the family published two years later. A new "subgenus" (*Vesperimus* = genus *Peromyscus* Gloger, 1841), two new genera (*Ochetodon* = *Reithrodontomys* Giglioli, 1873, and *Evotomys*), and two new species were here characterized, and are still recognized, although earlier names have since been found for two of the genera.

During the following year he published additional taxonomic papers, including one entitled "On the Cranial and Dental Characters of Mephitinæ, with description of *Mephitis frontata* n. sp.

* "Notes on a Collection of Mammals from Arizona" (Proc. Acad. Nat. Sci. Philadelphia, 1867, pp. 133-136), and "The Quadrupeds of Arizona" (American Naturalist, I, 1867, pp. 281-292, 351-363, 393-400, 531-541).

† "Antero-posterior Symmetry, with special reference to the Muscles of the Limbs" (Medical Record, June–September, 1870, in eight instalments); "On the Myology of *Ornithorhynchus*" (Comm. Essex Inst., VI, 1871, pp. 128-173); "The Osteology and Myology of *Didelphis virginiana*" (Mem. Boston Soc. Nat. Hist., Vol. II, 1873, pp. 41-154), and "Notice of a Cyclopean Pig" (Proc. Acad. Nat. Sci. Philadelphia, 1869, pp. 93-101).

‡ "Notes on the Natural History of Fort Macon, N. C., and vicinity" (Proc. Acad. Nat. Sci. Philadelphia, 1871, pp. 12-49—mammals, pp. 12-18).

§ Proc. Acad. Nat. Sci. Philadelphia, 1874, pp. 173-196. Reissued as a repaged separate, with additions, 1874, pp. 1-28, retitled "U. S. Northern Boundary Commission * * * Natural History, No. 1. On the Muridæ."

foss."* The new species was based on a skull from the bone caves of Pennsylvania. This paper gave a review of the characters of the genera *Mephitis, Spilogale* and *Conepatus,* of which only a single North American species of each was here recognized. This was shortly followed by "Some Account, critical, descriptive, and historical, of *Zapus hudsonius,*"† in which the jumping mice of North America were first separated from the Jerboas of the Old World under the new generic name, *Zapus,* and as a new family, Zapodidæ. This paper, like others published at about this time, was preliminary to his monographic treatment of various families of North American rodents, published in 1877, in volume XI of the final reports of the Hayden Survey, entitled "Monographs of North American Rodentia." These include his "Critical Review of the North American Saccomyidæ,"‡ and several papers on the family Geomyidæ,§ the one last cited in the accompanying footnote, however, being the full monograph of the family, reprinted in abstract only in "Monographs of North American Rodentia."

In 1875 he also published (with Dr. H. C. Yarrow) a report on the mammals collected on the Surveys West of the One Hundredth Meridian, under Lieut. George M. Wheeler, the report on the collections by the joint authors occupying pages 35-129 of volume V of the final "Report" of the Surveys.‖ The text relates mainly to the habits and geographical distribution of the mammals of the southwestern portions of the United States, with extensive tables of synonymy and bibliographic references. While now of course obsolete as regards the nomenclature, it is still the original source of much important information.

* Bull. U. S. Geol. and Geogr. Surv. Terr., 2d ser., No. 1, 1875, pp. 7-15, with 1 text-figure.

† Bull. U. S. Geol. and Geogr. Surv. Terr., 2d ser., No. 5, January 8, 1875, pp. 253-262.

‡ Proc. Acad. Nat. Sci. Philadelphia, 1875, pp. 227-327.

§ "The Cranial and Dental Characters of Geomyidæ." Bull. U. S. Geogr. and Geol. Surv. Terr., 2d ser., No. 2, May 11, 1875, pp. 83-90.

"Synopsis of the Geomyidæ." Proc. Acad. Nat. Sci. Philadelphia, 1875, pp. 130-138.

"Abstract of Results of a Study of the Genera *Geomys* and *Thomomys.*" Expl. of the Colorado River of the West, 1875, pp. 215-285, figs. 1-80.

‖ The volume as a whole was not issued till September, 1876.

He appears to have published nothing on mammals during the year 1876 that requires notice in the present connection, but in 1877 his output in this field was notable, consisting largely of matter prepared during the preceding year. This includes his "Precursory Notes on American Insectivorous Mammals, with description of a new Species,"* in which the genera and species were critically considered, and three new subgenera and five new species were characterized. This paper remained for many years the authoritative paper on the group. The other publications of this year, to be here noted, are Coues's well-known monograph, "Fur-bearing Animals of North America," and his several final monographs of various families of North American rodents.

The "Fur-bearing Animals" was issued as a special volume of the "Miscellaneous Publications" of the Hayden Survey, and was put forth "as a specimen fasciculus of a systematic History of North American Mammals," in which, as stated in the "Prefatory Note," it was "proposed to treat the mammals of North America, living and extinct, in the same comprehensive and thorough manner in which the single family of the Mustelidæ has [here] been elaborated." The form and character of the proposed final work is here outlined, namely, a concise treatment of the technical and critical portions of the subject, while those aspects of more general interest, such as the life histories and economic and other practical relations of the species to man, will be given in ample detail. Unfortunately, this scheme was never carried out, and until this day we have had no general work on the mammals of North America, considered from both the technical and popular standpoint, since the completion of Audubon and Bachman's "Quadruped of North America," issued in three volumes, royal octavo, in 1846-1854. Coues had at this time "been long engaged" upon such a work, and continued gathering material for it for several years more, when in 1880, when the work was far advanced toward completion, he was ordered to duty at Fort Whipple, and the several Government geological surveys were reorganized, and their scope so restricted as to exclude the proposed great work on North American mammals and other similar enterprises, which at this time had become a

* Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. III, 1877, pp. 631-653.

marked feature of the Hayden and other surveys. Had the work been completed and published, its taxonomy would have been soon obsolete, but the work as a whole would have formed a repository of general information on the mammals of North America, drawn from all then available sources, that would have been of great convenience and usefulness.

The comprehensive plan of the monograph of the Mustelidæ includes a consideration of their systematic position, their subfamily and generic subdivisions, with full diagnoses of these divisions and of the species, the derivation and signification of the names applied to them, both vernacular (in various languages) and technical, their geographical ranges, habits, economic products, and much interpolated matter relating to the allied foreign species, and much original information respecting special features of their anatomy. In short, it is an elaborate compendium of all that relates to the North American representatives of this especially important and interesting family of mammals, as then known.

The thick quarto volume of the Hayden Survey entitled "Monographs of North American Rodentia," comprised eleven monographs, of which the following five were by Dr. Coues: I, Muridæ (pp. i-iv+264); VII, Zapodidæ (pp. 455-479); VIII, Saccomyidæ (pp. 481-542); IX, Haplodontidæ (pp. 543-599); X, Geomyidæ (pp. 601-629). They were written, as well as the "Fur-bearing Animals," at the height of the wave of conservatism that engulfed American mammalogists and ornithologists alike between the years 1872 and 1882, in respect to the "species question."

But the results were far more disastrous in respect to the work of that period in the mammalogical field than in ornithology. It was unfortunately based on the assumption that the mammals and birds of North America were at that time well known, and that the then available material was sufficient for their critical, and perhaps final, revision; and not only this, that not only had all the species been described, but that far too many, especially in the case of mammals, had been recognized. Hence many of the then currently recognized species were properly reduced to "varieties" or subspecies, but many others, through lack of sufficient or properly prepared material and the wrong interpretation

of slight differences, and not infrequently the oversight of important characters in skulls that had not been taken out of the skins, were reduced to synonymy. More recent work in North American mammalogy, based on later-acquired and better-prepared material, from a multitude of new localities and many times greater in quantity, have shown how erroneous were the conclusions of 1877. New methods of field work, introduced by Merriam some years later, led to the discovery of not only a large number of new and markedly distinct specific types, but a considerable number of new genera and an endless list of new local forms or subspecies.* Whether or not the pendulum has not swung too far in the direction of ultra subdivision only time can disclose. But it still may be said of these monographs that the work was performed with the utmost conscientiousness and in accordance with the prevailing tendencies of the time, and under the handicap of extremely limited and wretchedly prepared material. The rejuvenation of mammalogy, both in this country and abroad, during the last twenty years, is due almost wholly—at least primarily—to the new methods of field work which originated in this country during the eighties and have since extended throughout the world. Yet the "Monographs of North American Rodentia" contain much of permanent value, especially in relation to the historical and bibliographical phases of the subject, and as a summary of previous knowledge of the groups treated.

About 1885 Dr. Coues's hitherto incessant intellectual activities in ornithology and mammalogy became diverted to other fields, and, with the exception of the preparation of the fifth edition of the "Key," which work, as already detailed, was then again rewritten, he ceased to impress, to any considerable extent, his personality upon either of these two branches of investigation.† Even his contributions to "The Auk" were few after 1888 (none in 1893 and 1894), and consisted mainly of reviews,

* For a fuller presentation of this phase of North American mammalogy, see my papers entitled "Recent Work in North American Mammalogy" (Trans. New York Acad. Sci., Vol. X, 1891, pp. 71-85) and "Recent Progress in the Study of North American Mammals" (Abstr. Proc. Linn. Soc. New York, No. 6, 1894, pp. 17-45).

† He wrote little on mammals after 1877.

short notes on questions of nomenclature, or historical references to early descriptions of American birds. The volume for 1897 is an exception, he having contributed to this some thirty or more short papers or notes, all of interest and a number of them, on questions of nomenclature, of considerable importance, some of them leading to nomenclatural changes in the American Ornithologists' Union Check-List.

For seven years (1884-1891) his energies and attention were absorbed by work on the "Century Dictionary" (6 volumes, 1889-1893), of which Dr. Coues was one of the collaborators, having charge of the departments of General Zoölogy, Biology, and Comparative Anatomy, and for which he furnished some 40,000 definitions and hundreds of illustrations, largely original, drawn under his supervision by Mr. E. T. Seton. In a review of this great work from the ornithological standpoint, the present writer stated, in 1891,* "The ornithological matter, both as regards text and cuts, forms a conspicuous feature of the work, which is practically an encyclopedia of ornithology. For those who know Dr. Coues's ability at giving the gist of a bird's history in a few happily worded sentences, it is unnecessary to say that a vast amount of information is compressed into the space of a few lines."

In March, 1897, Dr. Coues became associated with Mr. Walter A. Johnson in the editorship of an illustrated monthly magazine of ornithology, "The Osprey," published at Galesburg, Illinois, and later in New York city, to which journal he furnished a few reviews and short notes, beginning with volume I, No. 7, March, 1897. With the second number of volume III (October, 1898), the magazine changed ownership and the office of publication was transferred to Washington, where the magazine was continued under the editorship of Elliott Coues and Theodore Gill. This joint editorship, however, continued for only six numbers of volume III, when Dr. Coues's connection with the magazine wholly ceased. A glance at Dr. Coues's editorial and other contributions to these numbers seems to afford an explanation of his early retirement from the editorial sanctum.

Immediately following the completion of his work on the "Century Dictionary" Dr. Coues turned his attention to other

* Auk, VIII, pp. 222-224.

work in which for a long time he had had a deep interest—the early explorations west of the Mississippi River. As early as 1876 he published "An Account of the various Publications relating to the Travels of Lewis and Clark, with a Commentary on the Zoölogical Results of their Expedition,"* and in 1893 appeared his "History of the Expedition of Lewis and Clark," in four octavo volumes, continuously paged, with commentary on the geography, ethnology, and natural history of the route. His principal annotations on the natural history occur in chapter XXV (Vol. III), pp. 821-900. This was followed in 1895 by his "Expeditions of Zebulon Montgomery Pike" (3 vols., 8vo); in 1897, by the "Journals of Alexander Henry and David Thompson," for many years (1799-1814) officers of the Northwest Company (3 vols., roy. 8vo); in 1898, by the "Journal of Major Jacob Fowler" (1 vol., 8vo), and the "Personal Narrative of Charles Lapenteur," for forty years a fur trader on the upper Missouri (2 vols., 8vo); and in 1900, by the "Diary of Francisco Garcés," who traveled through the Indian Territory, Kansas, Colorado, and New Mexico in 1775-76 (2 vols., 8vo), the revision of the proof-sheets of which last was made in part during his last illness.

These works,† forming fifteen volumes, consist entirely, except in the case of the expeditions of Lewis and Clark and Pike, of previously unpublished material and form a mass of new and original information on early explorations in the West of the highest interest and importance. They are all copiously annotated in reference to the geography, ethnography, and general natural history of the regions traversed by these various explorers, with the usual care and accuracy characteristic of Coues's scientific and bibliographic writings. In order to secure geographical correctness as to localities and the precise routes traversed by several of these explorers, he traveled many thousands of miles over the same routes, these journeys including a personal examination of the route of Lewis and Clark, a canoe trip up the Mississippi to determine Pike's route to the head-

* Bull. U. S. Geol. and Geogr. Surv. Terr., No. 3, February, 1876, pp. 7-20.

† The titles are given in full in the "List of Works," etc., appended to this biography.

waters of that river, and an effort to locate the trail of Garcés. His admirable equipment for this kind of editorial work is beyond question, and these volumes will ever remain a monument to his industry and intimate knowledge of early conditions in the West, while the information thus made available provides a mine of wealth for future historians.

For a time Dr. Coues was deeply interested in spiritualistic and theosophical questions—a side of his nature little known to even his intimate scientific associates. He was president for a time (1885-1886) of the American Board of Control of the Theosophical Society of India and of the Psychical Science Congress of the World's Congress Auxiliary at Chicago in 1893. Despite his activities in other fields, he found time to prepare and publish various brochures along these lines, among which are: "Biogen, a Speculation on the Origin and Nature of Life" (1884); "The Dæmon of Darwin" (1884); "Buddhist Catechism" (1885); "Kuthumi" (1886); "Can Matter Think?" (1886); "A Woman in the Case" (1887); "Neuro-Myology" (with Shute, 1887); "Signs of the Times" (1888). His connection with the Theosophical Society was sundered in 1889 by his expulsion from the Society, which would seem to indicate that he had ceased to be in sympathy with its doctrines and claims.

Dr. Coues was intimately associated with the American Ornithologists' Union, he having been one of the three signers of the call for a meeting of American ornithologists in New York city in September, 1883, which resulted in the founding of the Union. He was its first vice-president for ten years, presiding, in the absence of the president, at its first meeting, it thus falling to his lot to appoint the six committees then established to take in hand as many different lines of special investigation.

Later (1893-1895) he held the office of president for three years, and was always a valued and efficient member of its council and for many years was chairman of one of its most important committees—that on the Nomenclature and Classification of North American Birds. He had also an important share in the work of drafting and perfecting its "Code of Nomenclature," published in 1886. Dr. Coues held honorary membership in a large number of scientific societies and academies, foreign as well

as American. His election to the National Academy of Sciences occurred in 1877, when he was thirty-four years old.

Dr. Coues was a man of fine physique and rare mental endowments. With an attractive personality, he had unusual gifts of expression, which rendered him a ready and effective public speaker, genial and vivacious in conversation, and a writer of marked originality and force. As a reviewer he was kind and considerate; his friendships often assumed the ardor of affection, and the kindness of his nature led him on many occasions to tender a helping hand to younger ornithological aspirants. As an antagonist he was sometimes bitter and unforgiving.* He detested shams and exposed them ruthlessly. Discovery of truth was the marked incentive of his labors, and he freely and frankly retracted his opinions when convinced that they were wrong. He was naturally conservative, yet was a leader in his special lines of research. He was impulsive and sometimes indiscreet, having some of the failings that usually accompany genius.

Dr. Coues's capacity for work was enormous—indeed, phenomenal if we consider his sedentary habits and disregard of the ordinary precautions of health—and the wonder is that he for so many years maintained a condition of such vigor. In addition to his regular daily literary output, he maintained a voluminous correspondence, writing with his own hand many letters of great length, in a style peculiarly brilliant and spicy—in short, *Couesian.* With all his apparent energy and ceaseless activities, his health at last gave way, and for some years before his death he was a sufferer from a complication of diseases. During the summer preceding his death he made a journey to New Mexico and Arizona to refresh his memory of the country described in the diary of Francisco Garcés, which he was editing for publication; this proved too arduous for his reduced powers of endurance, "and he was brought to Santa Fé in a rather critical condition, where for a month he was very ill, but in September came

* An unfortunate illustration is his controversy with the late Dr. T. M. Brewer, of which Dr. Coues himself said, twenty years after the death of his opponent: "The controversy [in the 'Sparrow War'] had become [in 1874] between Dr. Brewer and myself a personal feud, with the usual accompaniments in the way of sweetness and light" (*Osprey*, I, 1897, p. 124).

to Chicago,"* and later to Washington. His condition was already critical, and early in December he was taken to Johns Hopkins Hospital, Baltimore, where he "had to undergo two surgical operations for distinct disorders within a month of each other. He succumbed from exhaustion the second day after the later operation, and died on Christmas day," 1899.† Throughout his last illness he maintained a courageous spirit, bearing excessive pain without complaint, and wrote occasional letters to several of his intimate scientific friends up to almost the day of the final operation, expressing doubt as to the outcome; they proved to be his final letters of farewell.

Thus ended the life of one who had attained high eminence in several literary fields as well as in ornithology; one whose beneficial influence on the progress of North American ornithology, both technical and popular, has never been excelled, and whose work in other lines of research was varied, thorough, and conscientious, and will be of lasting influence.

Dr. Coues's near surviving relatives are his half-brother, Medical Director Samuel F. Coues, U. S. Navy (retired), of Cambridge, Massachusetts; his sister, Grace Darling (Coues) Estes (Mrs. Dana Estes), of Brookline, Massachusetts, and two sons and a daughter.

Dr. Coues married, first, May 3, 1867, in Columbia, South Carolina, Jane Augusta McKenney, daughter of Owen McKenney, of Rushford, New York, and, second, October 25, 1887, in Boston, Massachusetts, Mrs. Mary Emily Bates, who survived him, but died in 1906. Dr. Coues had five children, all by his first wife, two of whom died in infancy. The other three are: (1) Edith Louise (Coues) O'Shaughenessy, born January 31, 1868, in Columbia, South Carolina, wife of Mr. O'Shaughenessy of the American Embassy at Vienna; (2) Elliott Baird Coues, born January 19, 1872, at Baltimore, Maryland, who was graduated with the degree of M. D. at the Bellevue Medical College, New York, and is now residing in Europe (unmarried); (3) Beverly Drinkard Coues, born in November, 1878, in Washington, and now in Europe (unmarried).

* D. G. Elliot, in The Auk, Vol. XVIII, 1901, p. 9.

† Osprey, IV, January, 1900, p. 80.

LIST OF PRINCIPAL WORKS AND PAPERS.

From this list are omitted hundreds of reviews contributed by Dr. Coues to the "American Naturalist," "Bulletin of the Nuttall Ornithological Club," "The Auk," "Science," "The Osprey," the New York "Nation," Chicago "Field," "Forest and Stream," "The Oölogist," and other scientific and literary journals, and also hundreds of short notes and semi-popular articles on natural history subjects, published in the above-mentioned and in other journals and magazines.

The most important works and papers of this list have been noticed in the foregoing pages. The annotations following some of the titles are briefly explanatory or give simply the names of the new genera, new species and subspecies, etc., described in the works and papers to which they relate.

ORNITHOLOGY.

1861.

1. A Monograph of the Tringeæ of North America. Proc. Acad. Nat. Sci. Philadelphia, Vol. XIII, July, 1861, pp. 170-205.
   Actodromas bairdi (p. 194), sp. nov.
2. Notes on the Ornithology of Labrador. Proc. Acad. Nat. Sci. Philadelphia, Vol. XIII, August, 1861, pp. 215-257.
   Ægiothus fuscescens (p. 222), sp. nov.
3. A Monograph of the Genus *Ægiothus*, with descriptions of new Species. Proc. Acad. Nat. Sci. Philadelphia, Vol. XIII, November, 1861, pp. 373-390.
   Ægiothus rostratus (p. 378), *Æ. exilipes* (p. 385), spp. nov.

1862.

4. List of Birds ascertained to inhabit the District of Columbia, with the times of Arrival and Departure of such as are non-residents, and brief notices of Habits, etc. By Elliott Coues and D. Webster Prentiss. Sixteenth Ann. Rep. Smithsonian Institution, for 1861 (1862), pp. 399-421.
5. Synopsis of the North American Forms of the Colymbidæ and Podicipidæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XIV, April, 1862, pp. 226-233, 404.
   Æchmophorus (p. 229), gen. nov.

6. Revision of the Gulls [Larinæ] of North America; based upon specimens in the Museum of the Smithsonian Institution. Proc. Acad. Nat. Sci. Philadelphia, Vol. XIV, June, 1862, pp. 291-312.

   Larus smithsonianus (p. 296), sp. nov.

   Abstract of a monograph revised and published in the "Birds of the Northwest," 1874, pp. 589-662.

7. A Review of the Terns [Sterninæ] of North America. Proc. Acad. Nat. Sci. Philadelphia, Vol. XIV, December, 1862, pp. 535-559.

   Republished, with additions, in "Birds of the Northwest," 1874, pp. 662-717.

1863.

8. Additional Remarks on the North American *Ægiothi*. Proc. Acad. Nat. Sci. Philadelphia, Vol. XV, February, 1863, pp. 40, 41.

9. On the *Lestris richardsoni* of Swainson; with a Critical Review of the Subfamily Lestridinæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XV, May, 1863, pp. 121-138.

1864.

10. The Crania of *Colymbus torquatus* and *C. adamsii* compared. Proc. Acad. Nat. Sci. Philadelphia, Vol. XVI, February, 1864, pp. 21, 22.

11. A Critical Review of the Family Procellariidæ: Part I, embracing the Procellarieæ, or Stormy Petrels. Proc. Acad. Nat. Sci. Philadelphia, Vol. XVI, March, 1864, pp. 72-91.

    Cymochorea (p. 75), *Halocyptena* (p. 78), genn. nov.; *C. homochroa* (p. 77), *H. microsoma* (p. 79), spp. nov.

12. A Critical Review of the Family Procellariidæ: Part II, embracing the Puffineæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XVI, 1864, pp. 116-144.

    Nectris amaurosoma (p. 124), *Puffinus creatopus* (p. 131), *P. opisthomelas* (p. 139), spp. nov.

13. Notes on certain Central American Laridæ, collected by Mr. Osbert Salvin and Mr. F. Godman. Ibis, July, 1864, pp. 387-393.

1865.

14. Ornithology of a Prairie-Journey, and Notes on the Birds of Arizona. Ibis, April, 1865, pp. 157-165.

15. [Notes on Birds observed at Fort Whipple, Arizona]. Ibis, October, 1865, pp. 535-538.

    Extracts from a letter to the Editors. *Empidonax pygmæus* (p. 537), sp. nov.

1866.

16. List of the Birds of Fort Whipple, Arizona: with which are incorporated all other species ascertained to inhabit the Territory; with brief critical and field notes, descriptions of new species, etc. Proc. Acad. Nat. Sci. Philadelphia, Vol. XVIII, March, 1866, pp. 39-100.

    Fifty copies reissued, with new pagination and title page, as: "Prodrome of a Work on the Ornithology of Arizona Territory," pp. 1-64.

    Micrathene (p. 51), *Asyndesmus* (p. 55), *Podasocys* (p. 96), genn. nov.; *Mitrephorus pallescens* (p. 63 = *Empidonax pygmæus* Coues, 1865), *Vireo plumbeus* (p. 74), *V. vicinior* (p. 75), *V. pusillus* (p. 76), spp. nov., *Chrysomitris mexicanus* var. *arizonæ* (p. 82), var. nov.

17. A Critical Review of the Family Procellariidæ: Part III, embracing the Fulmareæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XVIII, March, 1866, pp. 25-33.

18. Critical Review of the Family Procellariidæ: Part IV, embracing the Æstrelateæ and Prioneæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XVIII, May, 1866, pp. 134-172.

    Pseudoprion (p. 164), gen. nov.

19. Critical Review of the Family Procellariidæ: Part V, embracing the Diomedeinæ and the Halodrominæ. With a General Supplement. Proc. Acad. Nat. Sci. Philadelphia, Vol. XVIII, May, 1866, pp. 172-197.

    Diomedea gilliana (p. 181), sp. nov.

20. The Osteology of the *Colymbus torquatus;* with notes on its Myology. Mem. Boston Soc. Nat. Hist., Vol. I, pt. ii, November, 1866, pp. 131-172.

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21. A Monograph of the Alcidæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XX, January, 1868, pp. 2-81, figg. 1-16.

    Simorhynchus cassini (p. 45), sp. nov.

22. List of Birds collected in Southern Arizona by Dr. E. Palmer; with remarks. Proc. Acad. Nat. Sci. Philadelphia, Vol. XX, January, 1868, pp. 81-85.

23. Synopsis of the Birds of South Carolina. Proc. Boston Soc. Nat. Hist., Vol. XII, October, 1868, pp. 104-127.

24. Catalogue of the Birds of North America contained in the Museum of the Essex Institute; with which is incorporated a List of the Birds of New England. With Brief Critical and Field Notes. Proc. Essex Inst., Vol. V, 1868, pp. 249-314.

25. Bird's-Eye Views. American Naturalist, Vol. II, December, 1868, pp. 505-513; Vol. II, January, 1869, pp. 571-583, figg.

    On the structure of the eye in birds.

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26. Seaside Homes. American Naturalist, Vol. III, September, 1869, pp. 337-349.
Breeding habits of *Sterna antillarum* and *Ægialites wilsonius*.
27. On Variation in the Genus *Ægiothus*. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXI, October, 1869, pp. 180-189.
Supplementary to No. 3, above.
28. On the Classification of Water Birds. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXI, December, 1869, pp. 193-218.

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29. The Clapper Rail [*Rallus crepitans*]. American Naturalist, Vol. III, January, 1870, pp. 600-607.
30. The Great Auk [*Alca impennis*]. American Naturalist, Vol. IV, March, 1870, p. 57.
31. The Natural History of *Quiscalus major*. Ibis, July, 1870, pp. 367-378.

1871.

32. Notes on the Natural History of Fort Macon, N. C., and Vicinity. No. I, Vertebrates. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXIII, May, 1871, pp. 12-49. (Birds, pp. 18-47.)
33. Progress of American Ornithology. American Naturalist, Vol. V, August, 1871, pp. 364-373.
A review of J. A. Allen's "On the Mammals and Winter Birds of East Florida" (Bull. Mus. Comp. Zoöl., Vol. II, No. 3, pp. 161-451, pll. iv-viii, April, 1871), with discussion of positions taken by this author. The main points here contested were soon after conceded and made the basis of his revisions of species in the first edition of the "Key," in 1872. The correspondence between the two authors during this period, would throw much light on the "new departure" that marked this period in American ornithology.
Pipilo alleni (footnote, p. 366), sp. nov.
34. The Yellow-headed Blackbird [*Xanthocephalus icterocephalus*]. American Naturalist, Vol. V, June, 1871, pp. 195-200 and fig.
34 *bis*. Bullock's Oriole [*Icterus bullocki*]. American Naturalist, November, 1871, pp. 678-682 and fig.
35. The Long-crested Jay [*Cyanura macrolopha*]. American Naturalist, Vol. V, December, 1871, pp. 770-775.

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36. Mechanism of Flexion and Extension in Birds' Wings. Proc. American Assoc. Adv. Sci., Vol. XX, for 1871 (1872), pp. 278-284, figg.

37. Observations on *Picicorvus columbianus.* Ibis, January, 1872, pp. 52-59.
38. Contribution to the History of the Blue Crow [*Gymnokitta cyanocephala*] of America. Ibis, April, 1872, pp. 152-158.
39. The Nest, Eggs, and Breeding Habits of *Harporhynchus crissalis.* American Naturalist, Vol. VI, June, 1872, pp. 370, 371.
40. A New Bird [*Glaucidium ferrugineum*] to the United States. American Naturalist, Vol. VI, June, 1872, p. 370.
41. Studies of the Tyrannidæ. Part I: Revision of the Species of *Myiarchus.* Proc. Acad. Nat. Sci. Philadelphia, Vol. XXIV, 1872, pp. 56-81.
42. Material for a Monograph of the Spheniscidæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXIV, September, 1872, pp. 170-212, pll. iv, v.
43. Key to North American Birds, containing a concise account of every species of Living and Fossil Bird at present known from the Continent north of the Mexican and United States Boundary. Illustrated by 6 steel plates and upwards of 250 woodcuts. By Elliott Coues, Assistant Surgeon, United States Army. Salem: Naturalists' Agency. New York: Dodd and Mead. Boston: Estes and Lauriat. 1872. 1 vol., imp. 8vo, 4 prel. ll., pp. 1-361, 1 l., pll. i-vi, figg. 1-238. (Pub. October, 1872.)

    Spizella socialis var. *arizonæ* (p. 143), *Ortyx virginianus* var. *floridanus* (p. 237), varr. nov.

1873.

44. Some United States Birds, New to Science, and other Things Ornithological. American Naturalist, Vol. VII, June, 1873, pp. 321-331, figg. 65-70.

    Peucæa carpalis (p. 322), *Harporhynchus bendirei* (p. 330), spp. nov.

45. New Avian Subclass [Odontornithes]. American Naturalist, Vol. VII, June, 1873, p. 364.
46. Color-variation in Birds Dependent upon Climatic Influences. American Naturalist, Vol. VII, July, 1873, pp. 415-418.
47. Notice of a Rare Bird [*Coturniculus lecontei*]. American Naturalist, Vol. VII, December, 1873, pp. 748, 749.
48. Notes on Two little-known Birds of the United States [*Centronyx bairdi, Anthus spraguii*]. American Naturalist, Vol. VII, November, 1873, pp. 695-697.
49. Report on the Prybilov Group, or Seal Islands, of Alaska. By Henry W. Elliott, Assistant, Treasury Department. Washington: Government Printing Office. 1873. 1 vol., oblong 4to. (Appendix: Ornithology of the Prybilov Islands. By Dr. Elliott Coues, U. S. A.)

This is the original edition. Other editions appeared in 1875. Not paged.

Tringa ptilocnemis, sp. nov.

50. A Check List of North American Birds. By Elliott Coues. Salem. Naturalists' Agency. 1873, 8vo, 2 prel. ll., pp. 1-137, 2 ll.

This is the original edition, separately published, December, 1873; also reissued with "Field Ornithology," 1874. (See No. 51.)

1874.

51. Field Ornithology. Comprising a Manual of instruction for procuring, preparing, and preserving Birds, and a Check List of North American Birds. By Dr. Elliott Coues, U. S. A. Salem: Naturalists' Agency. Boston: Estes & Lauriat. New York: Dodd & Mead. January, 1874. 1 vol., 8vo, pp. i-iv, 1-116, 1-137. (See No. 50.)

52. [On the Classification of Birds, with Characters of the Higher Groups, and Analytical Tables of North American Families.] Baird, Brewer, and Ridgway's Hist. North American Birds, Vol. I, 1874, pp. xiv-xxviii.

53. [Glossary of Technical Terms used in Descriptive Ornithology. Including a number of prominent Anatomical and Physiological Terms]. Baird, Brewer, and Ridgway's Hist. North American Birds, Vol. III, 1874, pp. 535-560.

54. Habits and Characteristics of Swainson's Buzzard [*Buteo swainsoni*]. American Naturalist, Vol. VIII, May, 1874, pp. 282-287.

55. [A Recently] New Species of North American Bird [*Tringa ptilocnemis*]. American Naturalist, Vol. VII, August, 1874, pp. 500, 501.

Republication of the original description. (See above, No. 49.)

56. New Variety of the Blue Grosbeak [*Guiraca cærulea eurhyncha*]. American Naturalist, Vol. VII, September, 1874, p. 563.

57. On the Nesting of Certain Hawks, etc. American Naturalist, Vol. VII, October, 1874, pp. 596-603.

Falco communis, Buteo swainsoni, Archibuteo ferrugineus, and other birds of Montana.

58. Birds of the Northwest: A Hand-book of the Ornithology of the Region drained by the Mississippi River and its Tributaries. By Elliott Coues, Captain and Assistant Surgeon, U. S. Army. U. S. Geol. and Geogr. Surv. Terr., Miscell. Publ. No. 3, 1874. 1 vol., 8vo, pp. i-xii, 1-791.

Eremophila alpestris b. *leucolæma* (p. 38), var. nov.

1875.

59. Fasti Ornithologiæ Redivivi. No. 1. Bartram's "Travels." Proc. Acad. Nat. Sci. Philadelphia, Vol. XXVII, 1875, pp. 338-358.
Claims tenability for twenty of Bartram's names of North American Birds. (See also No. 65.)
60. On the Breeding of Certain Birds [in Montana]. American Naturalist, Vol. IX, February, 1875, pp. 75-78.

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61. On the Breeding-habits, Nest, and Eggs, of the White-tailed Ptarmigan (*Lagopus leucurus*). Bull. U. S. Geol. and Geogr. Surv. Terr., 2d ser., No. 5, January, 1876, pp. 263-266.
62. An Account of the various Publications relating to the Travels of Lewis and Clarke, with a Commentary on the Zoölogical Results of their Expedition. Bull. U. S. Geol. and Geogr. Surv. Terr., 2d ser., No. 6, February, 1876, pp. 417-444.
63. Contributions to the Natural History of Kergulen Island, etc., Oology, etc. By J. H. Kidder and Elliott Coues. Bull. U. S. Nat. Mus., No. 3, February, 1876, pp. 7-20.
64. A study of *Chionis minor* with reference to its Structure and Systematic Position. By J. H. Kidder, U. S. N., and Elliott Coues, U. S. A. Bull. U. S. Nat. Mus., No. 3, February, 1876, pp. 85-116.
65. Reply to Mr. J. A. Allen's "Availability of certain Bartramian Names in Ornithology." American Naturalist, Vol. X, February, 1876, pp. 98-102. (See No. 59.)
66. The Labrador Duck [*Camptolæmus labradorius*]. American Naturalist, Vol. X, May, 1876, p. 303.
67. Notable Change of Habit of the Bank Swallow [*Stelgidopteryx serripennis*]. American Naturalist, Vol. X, June, 1876, pp. 372, 373.
68. Tarsal Envelope in *Campylorhynchus* and allied Genera. Bull. Nutt. Orn. Club, Vol. I, July, 1876, pp. 50, 51.
69. On the Number of Primaries in Oscines. Bull. Nutt. Orn. Club, Vol. I, September, 1876, pp. 60-63.

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70. Corrections of Nomenclature in the Genus *Siurus*. Bull. Nutt. Orn. Club, Vol. II, April, 1877, pp. 29-33.
71. Notes on the Ornithology of the Region about the Source of the Red River of Texas, from Observations made during the Explorations conducted by Lieut. E. H. Ruffner, Corps of Engineers, U. S. A. By C. A. H. McCauley, Lieut. Third United States Artillery. Annotated by Dr. Elliott Coues, U. S. A. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. II, May, 1877, pp. 655-695.

72. *Leptoptila albifrons*, a Pigeon new to the United States Fauna. Bull. Nutt. Orn. Club, Vol. II, 1877, pp. 82, 83.

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73. Notes on the Natural History of Fort Macon, N. C., and Vicinity. No. 4. By Drs. Elliott Coues and H. C. Yarrow. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXX, 1878, pp. 21-28. (Birds, pp. 22-24.)
74. Note on *Passerculus bairdi* and *P. princeps*. Bull. Nutt. Orn. Club, Vol. III, January, 1878, pp. 1-3, pl. col'd.
75. Notes on the Ornithology of the Lower Rio Grande of Texas, from Observations made during the season of 1877. By George B. Sennett. Edited, with Annotations, by Dr. Elliott Coues, U. S. A. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. IV, February, 1878, pp. 1-66.

    Parula nigrilora (p. 11), sp. nov.
76. On the Moult of the Bill and Palpebral Ornaments in *Fratercula arctica*. Bull. Nutt. Orn. Club, Vol. III, April, 1878, pp. 87-91.
77. The Eave, Cliff, or Crescent Swallow (*Petrochelidon lunifrons*). Bull. Nutt. Orn. Club, Vol. III, July, 1878, pp. 105-112.
78. Field-Notes on Birds observed in Dakota and Montana along the Forty-ninth Parallel during the seasons of 1873 and 1874. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. IV, July, 1878, pp. 545-662.
79. Birds of the Colorado Valley: A Repository of Scientific and Popular Information concerning North American Ornithology. Part I, Passeres to Laniidæ. Bibliographical Appendix. Miscellaneous Publ. No. 8, U. S. Geol. and Geogr. Surv. Terr., 1878, 8vo, pp. i-xvi, 1-807, figg. 1-70.

    Bibliographical Appendix also separate, pp. 1-218.

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80. Private Letters of Wilson, Ord and Bonaparte. Penn Monthly, Vol. X, June, 1879, pp. 443-455.

    Alexander Wilson to A. Lawson; G. Ord to A. Wilson; C. L. Bonaparte to A. Lawson.
81. History of the Evening Grosbeak [*Hesperiphona vespertina*]. Bull. Nutt. Orn. Club, Vol. IV, April, 1879, pp. 65-75.
82. On the Present Status of *Passer domesticus* in America, with Special Reference to the Western States and Territories. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. V, No. 2, September, 1879, pp. 175-193.
83. Second Instalment of American Ornithological Bibliography. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. V, September, 1879, pp. 239-330.

    Relates to the ornithology of Central and South America.

84. Note on the Black-capped Greenlet, *Vireo atricapillus* of Woodhouse. Bull. Nutt. Orn. Club, Vol. IV, July, 1879, pp. 193, 194, pl. i (colored).
85. Note on *Alle nigricans* Link. Bull. Nutt. Orn. Club, Vol. IV, October, 1879, p. 244.

    Alle Link (1806) antedates *Mergulus* Vieillot (1816) for *Alca alle* Linn.
86. Further Notes on the Ornithology of the Lower Rio Grande of Texas, from Observations made during the Spring of 1878. By George B. Sennett. Edited with Annotations, by Dr. Elliott Coues, U. S. A. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. V, November, 1879, pp. 371-440.

1880.

87. Sketch of North American Ornithology in 1879. American Naturalist, Vol. XIV, January, 1880, pp. 20-25.
88. On the Nesting in Missouri of *Empidonax acadicus* and *Empidonax trailli*. Bull. Nutt. Orn. Club, Vol. V, January, 1880, pp. 20-25.
89. Notes and Queries concerning the Nomenclature of North American Birds. Bull. Nutt. Orn. Club, Vol. V, April, 1880, pp. 95-102.
90. Further Light on the Moult of the Bill in certain Mormonidæ. Bull. Nutt. Orn. Club, Vol. V, April, 1880, pp. 127, 128.
91. Fourth Instalment of Ornithological Bibliography: being a List of Faunal Publications relating to British Birds. Proc. U. S. Nat. Mus., Vol. II, May, 1880, pp. 359-482.

    This instalment antedates the Third (see below, No. 93).
92. Note on *Grus fraterculus* of Cassin. Bull. Nutt. Orn. Club, Vol. V, July, 1880, p. 188.
93. Third Instalment of American Ornithological Bibliography. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. V, No. 4, September, 1880, pp. 521-1066.

    Systematic Ornithology; not published till after the Fourth Instalment (see above, No. 91).

1881-1883.

94. New England Bird Life, being a Manual of New England Ornithology, revised and edited from the Manuscript of Winfrid A. Stearns, Member of the Nuttall Ornithological Club, etc. By Dr. Elliott Coues, U. S. A., Member of the Academy, etc. Part I, Oscines. Boston: Lee and Shepard, Publishers; New York: Charles T. Dillingham. 1881, 1 vol. 8vo. Title and pp. 1-324, text figg. 1-56. Part II, Non-Oscinine Passeres, Birds of Prey, Game and Water Birds. 1 vol. 8vo, 1883, pp. 1-409, text figg. 1-88.

1882.

95. Note on *Mitrepahnes,* a new Generic Name. Bull. Nutt. Orn. Club, Vol. VII, 1882, p. 55.
    To replace *Mitrephorus* Sclater, preoccupied.

1883.

96. Generic and Specific Appellations of North American Birds. Bull. Nutt. Orn. Club, Vol. VII, 1883, pp. 178, 179.
97. Note on *Passerculus caboti.* Bull. Nutt. Orn. Club, Vol. VIII, 1883, p. 58.
    Young of *Melospiza palustris.*
98. Nest and Eggs of *Myiadestes townsendi.* Bull. Nutt. Orn. Club, Vol. VIII, 1883, p. 239.
99. A Hearing of Birds' Ears. Science, Vol. II, 1883, pp. 422-424, 552-554, 586-589, 9 text figg.
    The structure of the ear in birds.
100. On the Application of Trinomial Nomenclature to Zoölogy. Zoölogist, 3d ser., Vol. VIII, July, 1883, pp. 241-247.
101. Avifauna Columbiana: being a List of Birds ascertained to inhabit the District of Columbia, with the times of arrival and departure of such as are non-residents, and brief notices of habits, etc. The Second edition, revised to date, and entirely rewritten. By Elliott Coues, M. D., Ph. D., Professor of Anatomy in the National Medical College, etc., and D. Webster Prentiss, A. M., M. D., Professor of Materia Medica and Therapeutics in the National Medical College, etc. Bull. U. S. Nat. Mus., No. 26, 1883, 8vo, pp. 1-133, frontispiece, 100 text figg. and 4 maps.

1884.

102. Ornithophilologicalities. Auk, Vol. I, 1884, pp. 49-58, 140-144.
    Reply to a critique by Augustus C. Merriam on the philological portion of the "Coues Check List and Lexicon of North American Birds" (*ibid.*, pp. 36-49).
103. Trinomials are Necessary. Auk, Vol. I, 1884, pp. 197, 198.
104. On some new Terms recommended for use in Zoölogical Nomenclature. Auk, Vol. I, 1884, pp. 320-322.
105. Strickland as an Advocate of "Linnæus at '58." Auk, Vol. I, 1884, p. 400.
106. Key to North American Birds. Containing a concise account of every species of living and fossil bird at present known from the Continent north of the Mexican and United States Boundary, inclusive of Greenland. Second Edition, revised to date, and entirely rewritten: with which are incorporated General Ornithology: an outline of the structure and classi-

fication of birds, and Field Ornithology: a Manual of collecting, preparing, and preserving birds. Profusely illustrated. Boston: Estes and Lauriat. 1884. Royal 8vo, pp. i-xxx, 1-863, colored frontispiece (anatomy of pigeon), and 563 text figg.

1887.

107. Key to North American Birds. Containing a concise account of every species of living and fossil bird at present known from the Continent north of the Mexican and United States Boundary, inclusive of Greenland and Lower California, with which are incorporated General Ornithology: an outline of the structure and classification of birds; and Field Ornithology, a Manual of collecting, preparing, and preserving birds. The Third Edition, exhibiting the Nomenclature of the American Ornithologists' Union, and including descriptions of additional species, etc. Profusely illustrated. Boston: Estes and Lauriat. 1887. Roy. 8vo, pp. i-x, i-xxx, 1-895, colored frontispiece (anatomy of pigeon), and 561 text figg.

Main text same as 1884 ed., with new title-page, and new matter in an appendix (pp. 865-895).

1888.

108. New Forms of North American *Chordiles*. Auk, Vol. V, 1888, p. 37.

C. sennetti and *C. chapmani* spp. nov.

109. Note on Rostratulinæ [subfam. nov.]. Auk, Vol. V, 1888, p. 204.
110. Corydomorphæ [superfam. nov.]. Auk, Vol. V, 1888, p. 207.
111. Notes on the Nomenclature of the Muscles of Volation in Birds' Wings. Auk, Vol. V, 1888, pp. 435-437.

1889.

112. A new Generic Name for the Elf Owl [*Micropallas*, nom. nov.]. Auk, Vol. VI, 1889, p. 71.

To replace *Micrathene* Coues, 1866, preoccupied.

1890.

113. Key to North American Birds. Fourth Edition, 1890. Same as third edition, with the addition of a "Second Appendix," pp. 897-907, giving additional species and subspecies, and "notes every further change reported by the [American Ornithologists'] Union's Committee from 1887 to January [1890] inclusive."

1891.

114. *Scenopœetes densirostris* [nom. gen. nov.]. Auk, Vol. VIII, 1891, p. 115.

1895.

115. Gätke's "Heligoland." Auk, Vol. XII, 1895, pp. 322-346.
Review of the work, with an extended list of birds observed by Gätke at Heligoland.

1896.

116. Merrem's Work. Auk, Vol. XIII, 1896, pp. 265, 266.
Collation, and list of the birds described and figured in it.

1897.

117. *Zamelodia* against *Habia*. Auk, Vol. XIV, 1897, pp. 39-42.
118. *Asarcia spinosa*. Auk, Vol. XIV, 1897, p. 88.
Fulica spinosa Linn. 1758 = *Parra variabilis* Linn. 1766.
119. Cuculidæ of the A. O. U. List. Auk, Vol. XIV, 1897, pp. 90, 91.
Three subfamilies are recognized.
120. Authority for the Name *Myiarchus mexicanus*. Auk, Vol. XIV, 1897, p. 92.
M. mexicanus Baird a synonym of *M. cinerascens* Lawr.
121. *Ammodramus* (*Passerculus*) *sanctorum* Coues. Auk, Vol. XIV, 1897, p. 92.
The validity of the species affirmed, and *Ammodramus* (*Passerculus*) *sandwichensis wilsonianus* proposed as a new name for *A. s. savanna* (Wils.).
122. Rectifications of Synonymy in the Genus *Junco*. Auk, Vol. XIV, 1897, pp. 94, 95.
J. danbyi Coues, young of *J. aikeni; J. h. shufeldti* Coale = *J. h. connectens* Coues.
123. Characters of *Dendroica cærulescens cairnsi* Coues. Auk, Vol. XIV, 1897, pp. 96, 97.
D. c. cairnsi redescribed.
124. Note on the Genus *Lucar* Bartram. Auk, Vol. XIV, 1897, p. 97.
Lucar, it is claimed, should replace *Galeoscoptes* as the tenable generic name for the Catbird.
125. *Uria lomvia* in South Carolina. Auk, Vol. XIV, 1897, pp. 202, 203.
Believed to be the first record of the species for South Carolina.
126. Type locality of *Fuligula collaris*. Auk, Vol. XIV, 1897, pp. 206, 207.
Based on a British killed specimen.
127. *Dafilula*, a new Subgenus [for *Querquedula catoni* Sharpe]. Auk, Vol. XIV, 1897, p. 207.
128. *Branta bernicla glaucogastra*. Auk, Vol. XIV, 1897, pp. 207, 208.
Replaces typical *B. bernicla* in North America.
129. A North American Snipe [*Gallinago major*] New to the A. O. U. List. Auk, Vol. XIV, 1897, p. 209.

130. Status of *Helodromas ochropus* in the A. O. U. List. Auk, Vol. XIV, 1897, pp. 210, 211.
Recalls an early overlooked record.

131. Status of the Redshank [*Totanus totanus* (Linn.)] as a North American Bird. Auk, Vol. XIV, 1897, pp. 211, 212.
Attention called to an early record in "Fauna Boreali-Americana," Vol. II, 1831, p. 391.

132. Validity of the Genus *Lophortyx*. Auk, Vol. XIV, 1897, p. 215.
Considered to be a well characterized genus.

133. Notes on the Mexican Ground Dove. Auk, Vol. XIV, 1897, p. 215.
Columbigallina passerina pallescens (Baird) maintained as a good subspecies; also important comment on the generic name *Columbigallina*.

134. Note on *Elanus glaucus* [Barton]. Auk, Vol. XIV, 1897, p. 216.

135. Untenability of the Genus *Sylvania* Nutt. Auk, Vol. XIV, 1897, pp. 223, 224.
To be replaced by *Wilsonia* Bonap.

136. The most General Fault of the A. O. U. Check-List. Auk, Vol. XIV, 1897, pp. 229-231.
Respecting the sequence of genera and subfamilies within their respective families.

137. The Turkey Question. Auk, Vol. XIV, 1897, pp. 272-275.
Meleagris gallopavo Linn. restricted to the Mexican form.

138. Note on *Pagophila alba*. Auk, Vol. XIV, 1897, p. 313.
Pagophila Kaup urged as the proper generic name of the species, in place of *Gavia* Boie, untenable in this connection.

139. *Onychoprion*, not *Haliplana*. Auk, Vol. XIV, 1897, p. 314.
Both names based on the same species, the former having priority.

140. Remarks on certain Procellariidæ. Auk, Vol. XIV, 1897, pp. 314, 315.
On the number and sequence of the subfamilies, and on the status of some of the genera and species.

141. Bibliographical Note. Auk, Vol. XIV, 1897, pp. 327-329.
On the dates of Major Bendire's early indirect contributions to ornithological literature.

1898.

142. William Swainson to John James Audubon. Auk, Vol. XV, 1898, pp. 11-13.
A hitherto unpublished letter of Swainson's to Audubon, in reference to his proposed collaboration with Audubon in the preparation of the "Ornithological Biography."

143. Notes on the Generic Names of certain Swallows. Auk, Vol. XV, 1898, pp. 271, 272.

1899.

144. Note on *Meleagris gallopavo fera*. Auk, Vol. XVI, 1899, p. 77.
Addendum to No. 137, above, *q. v.*

145. The Finishing Stroke to Bartram. Auk, Vol. XVI, 1899, pp. 83, 84.
Comment on, and rejection of, current Bartramian names. *Catharista atrata* (Bartram) renamed *C. urubu* (Vieill.); *Aphelocoma floridana* (Bartram) renamed *A. cyanea* (Vieill.); *Corvus americanus floridanus* Baird renamed *C. a. pascuus* (nom. nov.).

146. On Certain Generic and Subgeneric Names in the A. O. U. Check-List. Osprey, Vol. III, 1899, p. 144.
Believes that a large number of the subgenera should be given full generic rank, and that several additional subgenera should be recognized.
Pallasicarbo and *Psiloscops*, subgenn. nov.

1900.

147. *Pipile vs. Pipilo.* Auk, Vol. XVII, 1900, p. 65.
Pipile replaced by *Cumana*, nom. gen. nov.

148. *Strix vs. Aluco.* Auk, Vol. XVII, 1900, pp. 65, 66.
The two names should be transposed, as also the names of the two families to which they respectively belong; a transposition officially adopted by the A. O. U. Committee in 1908 (*cf.* Auk, Vol. XXV, 1908, pp. 288-291, 370).

1901.

149. Audubonlana, and Other Matters of Present Interest. Bird-Lore, Vol. III, 1901, pp. 9-13.
An address delivered before the American Ornithologists' Union, at the annual meeting held in New York City, November 10, 1897; only the part relating to Audubon here reproduced from a stenographic report, with portrait of Coues.

1903.

150. Key to North American Birds. Containing a concise account of every species of Living and Fossil Bird at present known from the Continent north of the Mexican and United States Boundary, inclusive of Greenland and Lower California. With which are incorporated General Ornithology: an outline of the Structure and Classification of Birds; and Field Ornithology, a Manual of collecting, preparing, and preserving Birds. The Fifth Edition (entirely revised), exhibiting the Nomenclature of the American Ornithologists' Union, and

including descriptions of additional species. In Two Volumes. By Elliott Coues, A. M., M. D., Ph. D., Late Captain and Assistant Surgeon U. S. Army and Secretary U. S. Geological Survey; Vice-President of the American Ornithologists' Union, and Chairman of the Committee on the Classification and Nomenclature of North American Birds; Foreign Member of the British Ornithologists' Union; Corresponding Member of the Zoölogical Society of London; Member of the National Academy of Sciences, of the Faculty of the National Medical College, of the Philosophical and Biological Societies of Washington. Profusely illustrated. Boston: Dana Estes and Company. 1903. 2 vols. roy. 8vo, Vol. I, pp. i-xli, 1-535, col. frontispiece (portrait of Author), and text figg. 1-353; Vol. II, pp. i-vi, 537-1152, col. frontispiece, and text figg. 354-747.

Stellerocitta, Sieberocitta, Dilopholieus, Viguacarbo, subgenn. nov.

MAMMALOGY.

1867.

151. The Quadrupeds of Arizona. American Naturalist, Vol. I, 1867, pp. 281-292, 351-363, 393-400, 531-541.

    Extended notes on habits and distribution. *Sciurus arizonensis* (p. 537), sp. nov.

152. Notes on a Collection of Mammals from Arizona. Proc. Acad. Nat. Sci. Philadelphia, Vol. XIX, 1867, pp. 133-136.

    Brief field notes on 28 species.

1869.

153. Observations on the Marsh Hare. Proc. Boston Soc. Nat. Hist., Vol. XIII, 1869, pp. 86-95.

    Habits, external and cranial characters of *Lepus palustris* Bachm.

154. Notice of a Cyclopean Pig. Proc. Boston Soc. Nat. Hist., Vol. XIII, 1869, pp. 93-100, with fig. of skull.

1870.

155. Antero-posterior Symmetry, with especial reference to the Muscles of the Limbs. N. Y. Med. Record, June-September, 1870, pp. 149-152, 193-195, 222-224, 273, 274, 297-299, 370-372, 390, 391, 438-440.

1871.

156. Notes on the Natural History of Fort Macon, N. C., and Vicinity. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXIII, 1871, pp. 12-49. (Mammals, pp. 12-18.)

157. Former Eastward Range of the Buffalo [*Bison bison* (Linn.)]. American Naturalist, Vol. V, 1871, pp. 719, 720.

Former occurrence in West Virginia, as late as 1793-1798.

158. On the Myology of the Ornithorynchus. Comm. Essex Inst., Vol. VI, 1871, pp. 128-173.

1872.

159. The Osteology and Myology of *Didelphys virginiana*. With an Appendix on the Brain, by Jeffries Wyman. Mem. Boston Soc. Nat. Hist., Vol. II, 1872, pp. 41-154.

160. Geographical Distribution of *Bassaris astuta*. American Naturalist, Vol. VI, 1872, p. 364.

1873.

161. The Prairie Wolf, or Coyoté (*Canis latrans*). American Naturalist, Vol. VII, 1873, pp. 385-389.

Relationships with domestic dog.

162. Variation in Dentition. American Naturalist, Vol. VII, 1873, pp. 496, 497.

Supernumerary tooth in lower jaw of "*Canis lupus* L., race *occidentalis* Rich., strain *griseoalbus* Bd."

1874.

163. Synopsis of the Muridæ of North America. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXV, 1874, pp. 173-196.

Reissued (repaged) under the title "U. S. Northern Boundary Commission. * * * Natural History. No. I. On the Muridæ." pp. 1-28.

Ochetodon (p. 184), *Evotomys* (p. 186), genn. nov.; *Vesperimus* (p. 178), *Euneomys* (p. 185), subgenn. nov.; *Hesperomys* (*Vesperimus*) *melanophrys* (p. 181), *H.* (*Onychomys*) *torridus* (p. 183), spp. nov.

1875.

164. The Cranial and Dental Characters of Geomyidæ. Bull. U. S. Geol. and Geogr. Survey. Terr., 2d ser., No. 2, May, 1875, pp. 83-90.

Reprinted, with some modification, in "Monographs of North American Rodentia," in 1877.

165. A Critical Review of the North American Saccomyidæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXVI, 1875, pp. 272-327, 3 figures of ears of three species of *Perognathus*.

166. Synopsis of the Geomyidæ. Proc. Acad. Nat. Sci. Philadelphia, Vol. XXVI, 1875, pp. 130-138.

Thomomys clusius (pp. 135, 138), sp. nov.

Abstract of the memoir published in full in "North American Rodentia" in 1877.

167. Abstract of Results of a Study of the Genera *Geomys* and *Thomomys*. Expl. of Colorado River of the West, 1869-1872 (Powell), 1875, pp. 217-285, fig. 80.

Addendum A: "The cranial and dental characters of Geomyidæ," pp. 267-279, reprinted from Bull. U. S. Geol. and Geogr. Surv. Terr., 2d ser., No. 2, pp. 88-90, May 11, 1875. (See No. 164.)

Addendum B: Notes on the "Salamander of Florida (*Geomys tuza*)," by G. Brown Goode, pp. 281-285.

168. Report upon the collections of Mammals made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona during the years 1871, 1872, 1873, and 1874, by Dr. Elliott Coues and Dr. H. C. Yarrow. Rep. Expl. and Surv. West of the One Hundredth Meridian, Vol. V, 1875, pp. 35-129.

Notes on habits and geographical distribution, with extensive tables of synonymy and bibliographical citations for many of the species.

"*Cervus virginianus* var. *coucsi*, Rothrock, MSS.," p. 72, a provisional name, but the authors (p. 75) say they are "at present * * * indisposed to formally recognize this designation."

"Genus *Zapus* Coues MSS.," p. 99.

169. Some Account, Critical, descriptive, and historical, of *Zapus hudsonius*. Bull. U. S. Geol. and Geogr. Surv. Terr., 2d ser., No. 5, 1875, pp. 253-262.

Zapus, gen. nov.; Zapodidæ, fam. nov.

170. The Cranial and Dental Characters of Mephitinæ, with description of *Mephitis frontata*, n. sp. foss. Bull. U. S. Geol. and Geogr. Surv. Terr., 2d ser., No. 1, 1875, pp. 7-15.

171. The Prairie Gopher [*Spermophilus richardsoni*]. American Naturalist, Vol. IX, 1875, pp. 430-436.

172. Synonymy, Description, History, Distribution and Habits of the Prairie Hare [*Lepus campestris*]. Bull. Essex Inst., Vol. VII, 1875, pp. 73-85.

173. Chips from the Buffalo's Workshop. Forest and Stream, April 1, 1875.

A humorous skit, with much interesting information.

1877.

174. Precursory Notes on American Insectivorous Mammals. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. III, 1877, pp. 631-653.

Microsorex (ex Baird, MSS.), *Notiosorex* (ex Baird, MSS.), *Soriciscus*, subgenn. nov.; *Sorex pacificus* (ex Baird, MSS.), *S. sphagnicola*, *S.* (*Notiosorex*) *crawfordi* (ex Baird MSS.), *S.* (*N.*) *evotis*, *Blarina mexicana* (Baird MSS.), spp. nov.

175. Fur-bearing Animals: A Monograph of North American Mustelidæ, U. S. Geol. and Geogr. Surv. Terr. (Hayden), Miscel. Publ., No. 8, 1877, 8vo, pp. i-xiv, 1-348, pll. i-xx.

176. Monographs of North American Rodentia. By Elliott Coues and Joel Asaph Allen. Rep. U. S. Geol. and Geogr. Surv. Terr. (Hayden), Vol. XI, 1877, pp. i-xii, i-x, 1-1091, pll. i-vii.

Dr. Coues's portion includes: I, Muridæ, pp. i-x, 1-264, pll. i-v; VII, Zapodidæ, pp. 455-480; VIII, Saccomyidæ, pp. 481-542; IX, Haplodontidæ, pp. 543-600, pl. vi; X, Geomyidæ, pp. 601-630, pl. vii; also, Appendix B. Material for a Bibliography of North American Mammals, by Theodore Gill and Elliott Coues, pp. 951-1091.

Arvicola (*Pitymys*) *quasiater* (p. 226), sp. nov.

In the case of the Haplodontidæ, in addition to the usual systematic treatment, the skeletal and viseral anatomy of the single species then known are described at length.

1878.

177. Notes on the Mammals of Fort Sisseton, Dakota. By C. E. McChesney, M. D., Acting Assistant Surgeon, U. S. A. Annotated by Dr. Elliott Coues, U. S. A. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. IV, No. 1, February, 1878, pp. 201-218.

178. On Consolidation of the Hoofs in the Virginian Deer. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. IV, 1878, pp. 293, 294.

179. On a Breed of Solid-hoofed Pigs apparently established in Texas. Bull. Geol. and Geogr. Surv. Terr., Vol. IV, 1878, pp. 295-297, 1 text fig.

1879.

180. The Outer Ear of *Blarina brevicauda.* Amer. Journ. Otology, Vol. I, July, 1879, pp. —? (also as a repaged separate of 2 pp.).

180*a*. Notice of Mrs. [M. A.] Maxwell's Exhibit of Colorado Mammals. In: "On the Plains, and Among the Peaks; or, How Mrs. Maxwell made her Natural History Collection." By Mary Dartt. Philadelphia, 1879. Mammals, pp. 217-225.

An annotated list of the mammals (about 50 species) shown in the Colorado Exposition Collection at the Centennial Exposition held in Philadelphia in 1876, and exhibited later in Washington, D. C., during the winter of 1876-7.

HERPETOLOGY.

1871.

181. Notes on the Natural History of Fort Macon, N. C., and Vicinity. No. 1. Proc. Acad. Nat. Sci. Philadelphia, pp. 12-49.
Reptiles, pp. 47-49—an annotated list of 11 species.

1876.

182. Synopsis of the Reptiles and Batrachians of Arizona; with critical and field notes, and an extensive synonymy, by Dr. Elliott Coues, U. S. A. Rep. Expl. and Surv. West of the One Hundredth Meridian, Vol. V, 1875, pp. 585-633, pll. xvi-xxv.
Volume not issued till 1876. A note by the author on p. 588 bears date "November 15, 1875."

1878.

183. Notes on the Herpetology of Dakota and Montana. By Drs. Elliott Coues and H. C. Yarrow. Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. IV, No. 1, February, 1878, pp. 259-291.
Eutænia radix twiningi (p. 279), subsp. nov.

GENERAL BIOLOGY.

1889-1893.

184. The Century Dictionary, an Encyclopedic Lexicon of the English Language. Prepared under the superintendence of William Dwight Whitney, Ph. D., LL.D., Professor of Comparative Philology and Sanskrit in Yale University. 8 vols.,* fol. New York: The Century Company. 1889-1893.

"The definitions of that part of general biological science which in any way relates to animal life or structure, including systematic zoölogy, have been written by Dr. Elliott Coues, who has been assisted in ichthyology and conchology by Prof. Theodore N. Gill, in entomology by Mr. Leland O. Howard and Mr. Herbert L. Smith, and in human anatomy by Prof. James K. Thacher. Special aid has also been received from other naturalists, particularly from Prof. Charles V. Riley. * * *—Preface, p. xiii.

Dr. Coues had special charge of "General Zoölogy, Biology, and Comparative Anatomy," to which subjects he contributed, it has been stated, some 40,000 definitions. This labor occupied nearly his entire time for seven years—1884-1891.

*Excluding Vol. IX, Cyclopedia of Names, and Vol. X, Atlas.

EDITOR AND ANNOTATOR OF JOURNALS OF EARLY EXPLORATIONS WEST OF THE MISSISSIPPI RIVER.

1893.

185. Descriptions of the Original Manuscript Journals and Field Notebooks of Lewis and Clark, on which was based Biddle's History of the Expedition of 1804-6, and which are now in the possession of the American Philosophical Society in Philadelphia. Proc. Amer. Philos. Soc., Vol. XXXI, 1893, pp. 17-33.

186. History of the Expedition under the command of Lewis and Clark, to the sources of the Mississippi River, thence across the Rocky Mountains and down the Columbia River to the Pacific Ocean, performed during the years 1804-5-6, by order of the Government of the United States. A new edition faithfully reprinted from the only authorized edition of 1814, with copious critical commentary, prepared upon examination of unpublished official archives and many other sources of information, including a diligent study of the original manuscript Journals and Field Notebooks of the Explorers, together with a new Biographical and Bibliographical Introduction, new Maps, and other illustrations, and a complete Index. By Elliott Coues, * * * Member of the National Academy of Sciences, etc. Four volumes, 8vo. New York: Francis P. Harper, 1893. Vol. I, pp. i-cxxxii, 1-352, frontispiece (portrait of Meriwether Lewis); Vol. II, pp. i-vi, 353-820, frontispiece (portrait of William Clark); Vol. III, pp. i-vi, 821-1298; Vol. IV, pp. i-v, 1299-1364, 6 small maps, reproduced in facsimile from the Philadelphia edition of 1814, 2 large folding maps (in pocket of cover), and 2 genealogical tables (folded inserts) of the descendants and living issue of William Clark.

1895.

187. The Expeditions of Zebulon Montgomery Pike, to the Headwaters of the Mississippi River, through Louisiana Territory, and New Spain, during the years 1805-6-7. A new edition, now first reprinted in full from the original of 1810, with copious critical commentary, new memoir of Pike, new map and other illustrations, and complete index, by Elliott Coues. * * * Three volumes, 8vo. New York: Francis P. Harper, 1895. Vol. I, Memoir of the Author—Mississippi Voyage: pp. i-xviii,* xix-cxiv, 1-356, frontispiece (portrait of Pike); Vol. II, Arkansaw Journey—Mexican Tour: pp. i-vi, 357-855; Vol. III, Index—Maps: 4 ll., pp. 857-955, 7 maps in pocket.

1897.

188. New Light on the Early History of the Greater Northwest. The Manuscript Journals of Alexander Henry, Fur Trader of the Northwest Company, and of David Thompson, Official Geographer and Explorer of the same Company, 1799-1814. Exploration and Adventure among the Indians on the Red, Saskatchewan, Missouri, and Columbia Rivers. Edited with copious critical commentary by Elliott Coues, Editor of "Lewis and Clark," of "Pike," etc., etc. Three volumes, 8vo. New York: Francis P. Harper. 1897. Vol. I, the Red River of the North, pp. i-xxviii, 1-446, portrait of the Editor; Vol. II, The Saskatchewan and Columbia Rivers, pp. i-vi, 447-916; Vol. III, Index and Maps, 3 ll., pp. 917-1027, map (in 3 sections) in pocket.

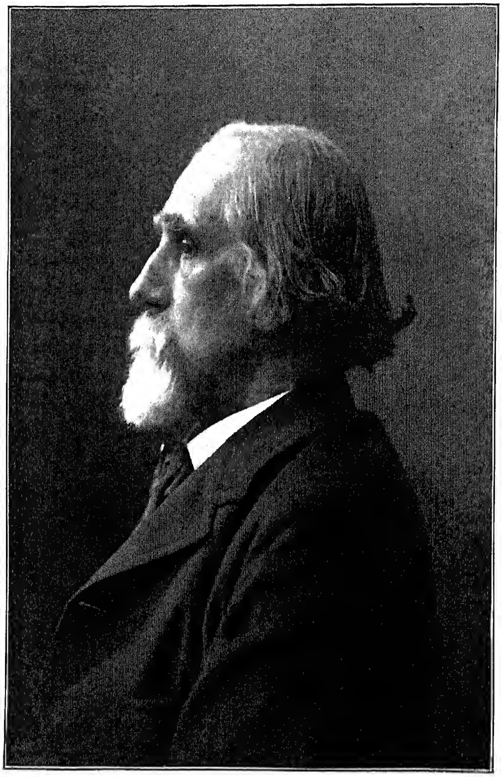
1898.

189. The Journal of Major Jacob Fowler, narrating an Adventure from Arkansas through the Indian Territory, Oklahoma, Kansas, Colorado, and New Mexico to the sources of Rio Grande del Norte, 1821-22. Edited, with notes, by Elliott Coues. New York: Francis P. Harper. 1898. 8vo, pp. i-xxiv, 1-183.

190. Forty Years a Fur Trader on the Upper Missouri. The Personal Narrative of Charles Larpenteur, 1833-1872. Edited, with many critical notes, by Elliott Coues. Maps, views, and portraits. Two volumes, 8vo. New York: Francis P. Harper. 1898. Vol. I, pp. i-xxvii, 1-236, portraits of Charles Larpenteur and Pierre Garreau, and 5 views; Vol. II, pp. i-ix, 237-472, 5 portraits, 5 maps, and view of old Fort Pembina.

1900.

191. On the Trail of a Spanish Pioneer. The Diary and Itinerary of Francisco Garcés (Missionary Priest) in his Journey through Sonora, Arizona, and California, 1775-76. Translated from an official contemporaneous copy of the original Spanish Manuscript, and edited, with copious critical notes, by Elliott Coues, Editor, * * * etc. Eighteen maps, views, and facsimiles. Two volumes, 8vo. New York: Francis P. Harper. 1900. Vol. I, pp. i-xxx, 1-312, 2 maps, 2 facsimiles, and 4 views; Vol. II, pp. i-vii, 313-608, frontispiece, 8 views, and 1 map.



Ogden N. Rood

NATIONAL ACADEMY OF SCIENCES
BIOGRAPHICAL MEMOIRS
PART OF VOLUME VI

BIOGRAPHICAL MEMOIR

OF

OGDEN NICHOLAS ROOD

1831-1902

BY

EDWARD L. NICHOLS

READ BEFORE THE NATIONAL ACADEMY OF SCIENCES
APRIL, 1909

CITY OF WASHINGTON
PUBLISHED BY THE NATIONAL ACADEMY OF SCIENCES
August, 1909

NATIONAL ACADEMY OF SCIENCES.

Of the biographical memoirs which are to be included in Volume VI, the following have already been issued:

WASHINGTON, D. C.

JUDD & DETWEILER, INC., PRINTERS.

1909.

BIOGRAPHICAL MEMOIR OF OGDEN NICHOLAS ROOD.

OGDEN NICHOLAS ROOD, member of the National Academy of Sciences since 1865, was born at Danbury, Connecticut, February 3, 1831. Professor Rood was of Scottish descent, the family having lived near Edinburgh. They came to this country at an early day in the colonial period and settled at Lanesboro, Massachusetts. A few years before the Revolutionary War, one member of the family, Azariah Rood, purchased a tract of land in the town of Jericho, Vermont. His was the third family to settle in that neighborhood, and during the Revolution his house was the most northerly inhabited point in the State and subject to frequent attacks by the Indians. On this account the family was forced to abandon the property and to return to Lanesboro until after the close of the war. Professor Rood's father, the Reverend Anson Rood, was a grandson of Azariah Rood and one of a family of eight sons. Anson Rood was educated by his older brother, Dr. Herman Rood, who was one of the early biblical scholars of this country and who was for many years Professor of Hebrew in Dartmouth College. After graduation from that institution Anson Rood entered the ministry of the Congregational Church and was ordained at Danbury, Connecticut, in 1829, two years before the birth of his son, Ogden Nicholas Rood.

On his mother's side, Professor Rood was likewise descended from a family active in the intellectual and practical life of colonial times. His mother, Alida Gouveneur Ogden Rood, was a direct descendant of John Ogden (1610-88), the first of his name in America, who was one of the founders of Elizabeth, New Jersey, and who afterwards settled at Hempstead, Long Island, and in 1650 became one of the magistrates of the colony of Connecticut.

Professor Rood was graduated at Princeton College in 1852. During the two following years he was successively a graduate student at Yale, an assistant at the University of Virginia, and an assistant to Professor Silliman. His preparation for work as a physicist was completed by four years of study in Germany

(1854-58), a period which was divided between scientific study at the universities of Berlin and Munich and practice in oil painting.

The year 1858 was an eventful one. In it he married Miss Prunner, of Munich, returned to the United States, and entered upon his profession as a teacher. His first appointment, as Professor of Chemistry in the newly organized and short-lived institution known as the University of Troy (New York), was well calculated to bring out the innate qualities of the man. Some men become investigators merely under the stress of outward demand. They force themselves to research from sense of duty, from motives of ambition, for recognition, or to gain place. Not so Rood, who was increasingly productive under the most trying circumstances and when no original work was expected of him. His motive and the passion for research which filled him is finely voiced in his inaugural address at Troy, delivered July 20, 1859:*

"The mere desire of wealth, though it may influence many to touch lightly on the surface of these studies (the physical sciences), still is not a motive of sufficient strength to enable one to toil a lifetime, content with such rewards merely as are found in the pursuit itself. This calls for a more powerful and nobler motive—and it is found in the intense desire to solve some of the profound mysteries with which we are surrounded, in the longing to obtain some glimpses into the inner world, into the secret laboratory of nature. And now it would be proper, having indicated these lesser advantages, to speak of the nobler end of such study, of its beautiful and spiritual purpose; to speak of natural philosophy as a revelation from 'The great God, who maketh and doeth all things well.' But if you have not listened to His voice, speaking in His yellow sunbeam; in His banded rainbows and purple sunsets; in the violet flash of His lightning, and in the war of His tempests; or in His white crystalline snow with its blue shadows, and in His dark rivers congealed into transparent highways, solid as the rock; neither would you meditate on any crude thoughts that I might suggest."

These words were spoken in an environment as foreign to such ideals as well can be imagined, for the Troy University of that date—and its days were even then numbered—was, to quote the

* Columbia University Quarterly, December, 1902. Notice of Ogden N. Rood, by J. H. Van Amringe.

words of Dr. Vincent, of the Union Theological Seminary, spoken at Rood's funeral, "in its first crude stage, lodged in a huge, pretentious and uncomfortable building and almost devoid of the ordinary appliances of a common school."*

In the same tribute to his friend and former colleague Dr. Vincent gives a vivid picture of the surroundings into which the young physicist had been injected by fate:

"I shall never forget" (he says) "his unconcealed and vigorously expressed disgust when, fresh from the plethoric libraries and well-appointed laboratories of a German university, he found himself, with the title of Professor of Chemistry, in a so-called library, where four or five hundred volumes, chiefly of classical authors, were displayed on a dreary expanse of shelving; in an ill-lighted lecture-room with a few bottles of chemicals, and with a handful of students, half trained in country academies, and the most of them without any interest whatever in what he was appointed to teach them.

"But even under these depressing conditions his native energy, versatility, and fertility of resource displayed themselves. The apparatus which the poverty-stricken college could not furnish him, he manufactured with his own hands, enough at least to meet the very limited requirements. To those students who cared nothing for chemistry or physics, he was simply and serenely indifferent. He was a conscientious teacher, and any one who desired to learn, might learn; but very few desired to learn, and he quietly filled his class-register with zeros, which marked the numerous pitiable displays in his lecture-room. But when he did, now and then, meet with a student who showed an interest in his teaching, there were no lengths to which he would not go to instruct, encourage, and advance him. He would devote himself to him in hours and out of hours. He would take him to his private room, and lecture to him, and experiment with him, and lend him books, and all this, week after week, as though he had no object in his professional life beyond the proficiency of that particular subject.

"Separated in some degree, by our situation, from the social life of the city, the members of the faculty were thrown very much upon each other, and our relations were very intimate. Naturally inclined to solitude, he (Rood) proved himself, nevertheless, a most genial, stimulating, cheerful, and appreciative companion. No one would have thought of setting him down as a recluse. He was always ready to exchange a jest, and to see

* Dr. Martin E. Vincent, Columbia University Quarterly, December, 1892, p. 57.

the humorous side of a thing; and yet one was always conscious of an undercurrent of serious purpose. Into the narrow life of the infant college he threw himself with enthusiasm. He treated the various annoyances, inconveniences, and hardships with a kind of grim humor and tolerance, and he made the best of everything, and extracted from his experience a great deal of real enjoyment and solid achievement.

"Apparently one of the idlest and most indifferent of men at times, he was really one of the most busy and intent of men at all times. Often, when he appeared to be merely amusing himself, he was most hard at work in some definite direction. For months at a time he would spend many hours of each day with his rifle, at a rough shooting gallery among the hills back of the college, strolling leisurely homeward toward sundown with his paper targets in his hand; but by and by appeared a careful treatise on the American rifle. On a ramble, or while engaged with any piece of mechanical work, his eyes were continually busy noting phenomena, and divining new laws and principles; and the results of these observations were continually coming to light in papers in the American Journal of Science and Arts. Now he was experimenting with the stauroscope; again, while grinding a microscopic slide, he was noting the muscular contraction induced by contact with vibrating bodies, and comparing the symptoms and sensations produced by electricity and by mechanical vibration. Then his attention was directed to the phenomena of circulation in the eye. In his reading about Australia, the boomerang awakened his curiosity; and he set himself to study the principle of that barbarous instrument, and might often be seen on the college campus throwing the models he had prepared and studying their curves as they flew outward and returned. During the whole time of his residence in Troy he was studying the infant science of photography, wandering over the hills with his camera, photographing all sorts of objects, experimenting on all sorts of processes, and recording and tabulating innumerable data.

"And when he had found something, his instinct was to go and tell it. Without any such intention, he managed to draw us all into the current of his own interest. His enthusiasm was contagious, even to those who possessed little scientific knowledge. The ardor of a true huntsman is kindled by companionship. His life was one perpetual chase of the facts and laws of the physical universe; and though his zeal would have sustained him in a lonely pursuit, his pleasure was greatly enhanced by the intelligent sympathy of another. He liked to awaken the interest of even a mere boy in what he was doing. One day, some years ago, I went to see him in his laboratory, having with me a

lad of sixteen who was preparing to enter the School of Mines. He kept us there for something like two hours, showing the boy all kinds of wonders in the laboratory, especially the operation of the Röntgen rays, on which he was then experimenting.

"His zeal in the pursuit of physical science was intense and consuming, and never slackened while he lived. The more closely Nature guarded a secret, the more obstinately was he bent on discovering the master-key. He was impatient of everything superficial. He desired, and was determined to know, not only facts, but laws; not only laws, but ultimate principles. Even at that early period of his career he was *en rapport* with various notable specialists and high authorities and was occasionally visited by them at Troy."

Many who have witnessed or taken part in the development of scientific investigation in America will recognize this description as characteristic not merely of the ill-fated institution where Rood served his apprenticeship, but of the conditions which existed in nearly all American colleges of the period. Such scientific work as was done was due to men in whom the unquenchable fire burned and who were independent of environment. Such a man was Joseph Henry, much of whose most important work was done years before, in the academy of the neighboring town of Albany. Such in later years was Brace, who built up a great center for physical research on the Nebraskan frontier. That Rood was such a spirit, indomitable and irrepressible, the notable series of papers published by him during his four years at Troy bear witness.

PAPERS OF THE TROY EPOCH.

To this period belong a very interesting group of notes and communications, some of the latter in the form of letters to Silliman and to Wolcott Gibbs, which appeared in the American Journal of Science.

The first of these papers, dated at Troy, on Christmas day, 1858, describes a study of the polarization of light by passage through glass strained by sudden cooling. The article, although based on the work of von Kobell and of Dove, considerably extends and supplements their observations, and it contains in addition a new and ingenious method for the detection of circular polarization.

It was during this period that Rood made his first excursions into the realm of physiological optics—a domain in which he was later to travel far and make notable conquests. In 1860 he investigated the after-images produced by observing a bright sky through open sectors in a revolving disk, demonstrated their subjective character in contravention of the views of J. Smith, and showed the relation of the phenomenon to those previously observed by Fechner.

His explanation, which was based upon persistence of vision, is noteworthy: "The occurrence and sequence of these subjective colors," he says, "may easily be explained by supposing that during the interval of rest or shadow the action of the yellow rays diminishes more rapidly than that of the red, the red more rapidly again than that of the blue." In his Modern Chromatics* Rood subsequently outlined a method for testing this supposition, although he does not appear to have performed the experiment. When, however, persistence of vision as a function of the wave length of the exciting light was first definitely determined, in 1884,† the facts were found to agree with the assumption quoted above.

Rood's experience as an art student in Munich brought the problems of vision and color very near to him from the first, and he was always considering the numerous themes that lie in the middle ground between physics and painting. In 1861 he published a note on the relation between our perception of distance and color, in which he ascribed the increased vividness of coloring apparent upon viewing a landscape with the head lying under the arm to the fact that one's sense of distance is lost and one looks as at a picture. This view he verified by observations through total reflecting prisms and in other ways. In the same year he made some experiments connected with Dove's theory of luster, in which he brought into combination in the stereoscopic field a variety of surfaces, such as tin-foil and yellow paper, which gave the effect of gold leaf; of tin-foil and orange-colored paper, which when blended appeared like copper; of tin-foil combined with paper tinted with ultramarine, in which the com-

* Modern Chromatics, p. 206.

† Nichols, Am. Journal Science (3), XXVIII, p. 243.

posite image had the appearance of graphite. He found that a photograph of a surface of tin-foil, which gave a suggestion of metallic structure, served almost as well as the foil itself, although gray paper would not produce the effect. He also described experiments for the production of luster in which only one eye was used.

His paper on the practical application of photography to the microscope, which likewise appeared in 1861, was one of the earliest contributions to this subject. In it he described a simple but practical form of micro-camera with details of the still new art of wet-plate photography, printing, and the like. He also gave a method of making stereomicrographs and of photographing living organisms. The disagreement of opinion among microscopists as to the true character of the markings of *Pleurosigma angulatum* also attracted his attention, and by means of a magnifying power of a thousand diameters he succeeded in establishing the circular character of the lines of this infusorial shell as against the hexagonal. In order to determine more definitely than was possible by direct observation the character of microscopic forms, he applied the method of reflection commercially used in testing optical surfaces, and was thus able to settle certain points still in controversy.

During the year 1862 Rood was employed in the construction of a spectrometer with four large prisms—one of flint glass and three containing carbon bisulphide. With this instrument he obtained a spectrum 10 feet long and of excellent definition. In a letter to Wolcott Gibbs he described observations on the absorption spectrum of a solution of didymium nitrate, with which substance Gladstone had recently been experimenting. By the use of a strong solution and a cell twelve inches in thickness, Rood was able to find twelve bands instead of the two already observed. He also wrote an account of Dove's photometer, with some original suggestions as to the method of construction. His most important contribution during this year, however, was the very interesting paper on the study of electric sparks by aid of photography, in which "end on" views of the sparks were obtained by allowing the discharge to pass through the photographic film and then developing and enlarging the negative.

In 1863 the chair of Physics at Columbia College became vacant, and Rood was a candidate for this position. His chief competitor was F. A. P. Barnard, who became president of the college, while Rood was appointed to the professorship.

It was still the day of small things in science in America. Everywhere there was the same lack of equipment and but little time for or incentive to investigation. Even Columbia, one of the oldest of American institutions, which reached back to colonial times, was just emerging from the now almost inconceivable age of darkness, when one professor was thought to suffice for all the sciences.

PAPERS OF THE EARLIER YEARS AT COLUMBIA.

Rood's first scientific contribution after his transfer to New York was a brief but very lucid paper *on the green tint produced by mixing blue and yellow powders.*

After a statement of the older theory, based on the Newtonian primary colors, he quotes Helmholtz on the production of white by the mixing of yellow and blue light from the spectrum and gives his explanation of the green of the mixed pigments as due to absorption. This he verifies by observations with the spectroscope upon strips of paper painted with ultramarine, chrome yellow, and a mixture of the two. The color produced by whirling a disk with alternate sectors of the same yellow and green and the appearance of the spectrum of the light reflected from the revolving disk are described. A set of curves gives a semi-quantitative character to the results.

In July of the same year appeared his paper *on the production of thermo-electric currents by percussion.*

The chief interest in this paper lies in the illustration that it affords of the author's characteristics as an experimenter. The problem proposed was of the utmost simplicity; its answer obvious in advance: If a ball be allowed to fall upon a metal plate, the heat of impact will be proportional to the square of its velocity, and consequently to the height from which it falls. If this heat be developed in a thermo-junction, the current produced will afford a measure of the kinetic energy and should also be proportional to the height from which the ball falls. To attain this proportionality experimentally involves the fulfill-

ment of various conditions, and it is the clear insight into these and the very simple and sufficient means by which they are met that show the power and skill of Rood as a physicist and give the paper its value.

There followed in the same year an admirable experimental verification of Fresnel's explanation of the successive changes of color in the image of a source of white light when reflected at grazing incidence from a matte surface. Assuming with Fresnel that the color changes are due to interference, the angle at which the reflected image, after turning from white to red with decreasing incidence, disappears must depend upon the size of the particles of which the surface is made up. Rood measured this angle of disappearance in the case of various surfaces smoked with lampblack and a surface coated with magnesium oxide. He then compared the computed size of the reflecting particles with the size determined by measurement under the microscope and found the theory completely confirmed.

In the following year (August, 1867) appeared the first of Rood's papers read before the National Academy of Sciences. It formed the first part of his well-known memoir *on the nature and duration of the discharge of a Leyden jar connected with an induction coil.* Wheatstone's classical attempt to determine the duration of such discharges by means of a revolving mirror had been published more than thirty years before (1835), and Fedderson's, now equally classical and much more important investigations, which led to the discovery of the oscillatory discharge, had been described in 1858. Rood cleared up the discrepancy between the negative result of Wheatstone, who concluded that the duration of the spark was less than a millionth of a second, and Fedderson's greatly elongated and complex images of sparks as viewed with the revolving mirror, which showed durations of from .00004 to .00007 of a second. At the same time he extended the research, with many ingenious modifications of method, to the case of jars actuated by means of a coil, upon which phase of the subject nothing had been done.

The failure of Wheatstone to obtain the phenomena later described by Fedderson was shown to be due to his method, which really yielded measurements only of what we now call the pilot spark. This portion of the discharge, which Rood terms the

first explosive act, he studied with great refinement of method and he showed its duration to be certainly less than four-ten-millionths of a second.

This topic was to receive much further attention during the coming years, but in the meantime we find Rood busying himself with refinements and modifications of the Bunsen photometer. The results of these experiments form the subject of his next two papers.

In the summer of 1870 he availed himself of the opportunity offered by a violent thunder-storm to make an impromptu study of the duration of lightning. The hastily improvided apparatus consisted of a paper disk revolved by hand upon a hatpin as an axle. The speed of revolution was estimated at twelve turns per second, and the duration of some of the flashes was found to be about 1/500 of a second. A description of this experiment was communicated to the American Journal of Science in the form of a letter to Dr. Wolcott Gibbs.

Not contented with the experimental demonstration given in his first paper on the Leyden jar, that the duration of the pilot spark was less than four-ten-millionths of a second, Rood continued his attack upon the problem, and in June, 1871, he published measurements reaching down to the incredibly small interval of .000000040 seconds (forty-billionths of a second). The way in which this extraordinary sensitiveness of method was achieved can best be conveyed by a few quotations from the second paper:

"If two black lines of a certain breadth, inclosing between them a white line of equal breadth, be illuminated by the spark, and their images formed on the observing plate by the lens and mirror, the three lines will evidently be seen unaltered in appearance, provided, 1st, that the mirror is stationary or revolving at a sufficiently slow rate; or, 2d, the same effect will be produced with a rapidly revolving mirror and a truly instantaneous spark. If, however, the illumination of the spark last sufficiently long so that * * * superposition has been attained, then, owing to the retention of impressions on the retina, the distinction between the black and white lines will be obliterated and a tint of gray produced. * * * Instead of using only two lines, the same result can far more easily be attained by ruling paper with a large number of fine black lines equidistant and inclosing white spaces of their own breadth, as then the chances

for observation are greatly multiplied. * * * With the mirror revolving 340 times a second, using platinum points and a striking distance of two millimeters, the lines were still seen with an eyepiece, as bright and clear as though the mirror had been stationary, implying, as the apparatus was then arranged, a duration for the first act of less than three-ten-millionths of a second, which interval would have been required for destructive superposition. Nothing more could be done with paper, and accordingly I covered a glass glate with lampblack by smoking and poured upon it a few drops of alcohol, which, acting like a slight cement, enabled me to rule lines upon it with a dividing engine. After many trials and microscopic examinations a plate was produced with lines, black and white, of equal breadth, and the spark being discharged behind them, they were brightly illuminated. Their image was thrown upon the observing plate, and by using a sufficient magnifying power and counting, it was ascertained that the breadth of the image of a single line, black or white, was 1/12 of a millimeter. Hence the time required for their obliteration with a velocity of 340 per second was ninety-four-billionths of a second (.000000094); still on experimenting it was evident that the duration of the discharge was less than this quantity, as the lines were always plainly to be seen.

"Before finally abandoning the attempt to determine the actual duration of the discharge, another effort was made; a second lampblack plate was prepared, in which the breadth of the image of a line was 1/24 of a millimeter. * * * Platinum wires 1/86 of an inch in diameter were used with a striking distance of five millimeters; * * * it was proved successively that the duration was less than eighty, sixty-eight, fifty-nine, fifty-five-billionths of a second; and finally the lines, after growing fainter and fainter, entirely disappeared, giving as the result a duration of forty-eight-billionths of a second."

When the striking distance was reduced to one millimeter, the duration was found to be slightly greater than forty-one-billionths, at three millimeters it was between forty-one and forty-eight-billionths, and at ten millimeters' spark length it was between forty-eight and fifty-five-billionths of a second.

In connection with these investigations Rood published a brief note in which he called attention to the fact that these exceedingly minute durations of illumination by means of the electric spark not only sufficed for the mere production of the sensation of light, but likewise for the detection of somewhat intricate detail in the objects illuminated.

He also applied his method to further studies of the character of lightning and elaborated a very ingenious and precise method for the determination of the duration of oscillatory discharges. The apparatus which he devised for this purpose was of admirable simplicity. It consisted of a black disk with one narrow radial sector of white color. Mounted upon the same axle and traveling with it was a smaller disk, with a similar white sector, the position of which could be shifted about the shaft so as to give any desired angular displacement of the two sectors.

When at rest this combination appeared as a circular surface with a radial white line near the periphery and nearer the center a second radial white line with an angular displacement depending on the adjustment of the smaller disk. When in rapid revolution and illuminated by an oscillatory spark, two series of equally spaced white lines were seen, diminishing in intensity according to the factor of damping of the electric circuit. At a certain speed the tail of one of these groups would coincide radially with the head of the other and the velocity of the disk would then afford a measure of the duration of the train of oscillations.

With this device Rood greatly extended his studies of the oscillatory discharge. They brought him indeed to the very threshold of a great domain, but it was not yet thrown open for exploration. Maxwell's great work had not yet been published and the significance of certain fundamental equations in Helmholtz's earlier papers was not yet revealed. The needed theoretical foundation for the developments which were later to be made in this field had not yet been laid.

After the completion of these investigations, which chiefly occupied the period from 1869 to 1873, various minor papers appeared, including among others the following titles: *On secondary spectra* (1873); *On a convenient eyepiece micrometer* (1873); *On an optical method of studying the vibrations of solid bodies,* and *On a property of the retina first noticed by Mr. Tait* (1877).

A paper on the horizontal pendulum, which was printed in 1875, is especially notable. It illustrates the never-failing response of Rood's mind to the novel and ingenious in physics, his

admiration for a device or method of surpassing delicacy, and his passion for trying out such things when once suggested.

In this case the extraordinary results obtained by Zöllner with the horizontal pendulum stimulated him to the construction of an instrument based upon the same principle, but of his own design. The purpose seems to have been to see what degree of delicacy could be attained rather than the carrying out of any definite research. The result was an apparatus that surpassed even the more modern interferometer as a means of detecting minute differences of length. The probable error of single readings of the adjusting screw corresponded in some cases to 1/24,950,000 of an inch, or little more than 1/1,000,000 of a millimeter!

At this period Rood's scientific activity was, however, chiefly directed to physiological optics and the theories of color, and he busied himself with the studies which were soon to find masterly expression in the volume entitled *Modern Chromatics*. His article on the constants of color, which appeared in the Popular Science Monthly in 1876 and was reprinted in the Quarterly Journal of Science, has the same admirable simplicity of form and happy lucidity which characterizes his now classical volume on color. In this paper, after describing the three constants, *purity, luminosity*, and *hue*, and methods of determining each, he points out the enormous number (400,000,000) of variations distinguishable by the eye which may be obtained by changing, by barely sensible gradations, the saturation and brightness of all possible combinations of the hues of the spectrum. The substance of this paper was reproduced with little modification in *Modern Chromatics*, of which it forms the third chapter.

Modern Chromatics formed the culmination of Rood's many contributions to the physics of color, although he continued to the end of his life to practice painting, of which art he was a notable amateur. One problem, however, in this domain, that of the photometry of lights differing in color, he continued to ponder and investigate, and it was in this connection that, many years later, he made his greatest discovery.

The year of the issuing of *Modern Chromatics* (1879) was further notable for the publication of an ingenious and suggestive paper entitled *A method of studying the reflection of*

sound waves. This is one of the least known but at the same time most original and, in view of the possibilities which it affords for a quantitative investigation of the reflecting power of different surfaces, one of the most important of Rood's contributions to science.

The starting point of this research was the study of the familiar device of producing a tremulo effect in reed organs by means of a revolving paddle wheel or fan. The accepted explanation of the action of the attachment was erroneous, and Rood verified his surmise that it was really due to reflection of the sound waves from the surfaces of the revolving blades. He found not only that he could reproduce the tremulo by placing a revolving disk with open sectors behind a reed or other sounding instrument, but that the reflection, which was selective, could be obtained with a disk having alternating sectors of different materials. He was thus able to compare the reflecting powers of different surfaces.

MODERN CHROMATICS.

Rood's delightful volume, which appeared in 1879 under the title *Modern Chromatics,* is a masterpiece. Its lucidity and simplicity of treatment place it in the same rank with Tyndall's classical books on *Sound* and on *Light.* Like these, it is good literature as well as good science, and contains sound physics shorn of all unnecessary technicalities, and stated in terms easily comprehensible by any intelligent reader.

"It has been my endeavor also" (says the author in his preface) "to present in a simple and comprehensive manner the underlying facts upon which the artistic use of color necessarily depends. The possession of these facts will not enable people to become artists; but it may to some extent prevent ordinary persons, critics and even painters, from talking and writing about color in a loose, inaccurate, and not always rational manner. More than this is true; a real knowledge of elementary facts often serves to warn students of the presence of difficulties that are almost insurmountable, or, when they are already in trouble, points out to them its probable nature; in short, a certain amount of rudimentary information tends to save useless labor."

The book is full of telling illustrations gathered by a close observer of mountains, clouds, and sky, of foreground and dis-

tance, and of light and shade. The point of view is as often that of the painter as it is that of the physicist. This rare combination gives it a unique interest alike to the artist and the student of science. Speaking of the mixture of colors by the blending which occurs when small objects differing in tint are mingled at too great a distance for the discrimination of details, for example, the following passage occurs:

"Thus the colors of the scant herbage on a hillside often mingle themselves in this way with brown lines of the dried leaves; the reddish or purplish brown of the stems of small bushes unites at a little distance with their shaded green foliage; and in numberless other instances, such as the upper and lower portions of mosses, sunlit and shaded grass-stalks, and the variegated patches of color on rocks and trunks of trees, the same principle can be traced."

There are many such bits which serve a double purpose. They give the physics of effects familiar to the colorist of which he usually lacks the explanation and reveal effects unnoticed by the non-observant layman to whom the physics may be well known.

The point of view of the painter appears indeed in the most unlooked-for places, as in the chapter on the production of color by interference, where the color combinations seen in the observation of certain crystals are described. "They often astonish," we are told, "and dazzle by their audacity and total disregard of all known laws of chromatic composition. * * * They are laid on with such an unfaltering hand that all these wild freaks are performed comparatively with impunity."

The appeal of the author to readers of artistic training was such that *Modern Chromatics* was widely read by the painters of the time, both at home and abroad. This was the more remarkable, since it has always been difficult to persuade those who use color as a medium of expression to master the real physics of their subject.

The invasion of the impressionists occurred a few years later, and members of that school on both sides of the water assumed to find in Rood's treatise the philosophical basis of their method. In one sense they were right, for naturally any effects whatever that can be produced by the use of color must have a physical foundation. What Rood, however, to whom much of the work

of this school was abhorrent, thought of being hailed as the *father of impressionism* is told by his son, Mr. Roland Rood,* in an article in *The Scrip*. After pointing out the relations of the work of Constable and Turner to that of the impressionists, he adds:

"While acknowledging, however, their descent from the artists across the Channel, the impressionists count it their chief glory to have founded themselves upon science. They assert that they are the only painters who approach nature without a preconceived idea; that all they carry to it are the formulæ of Helmholtz, Chevreul, and Rood; and that of these it is Professor Rood, who in his work on color (including with his own researches those of Chevreul and Helmholtz) has done most for them. They refer to his work as 'The Impressionist's Bible,' and, as Mr. Van Ingen says in his lecture reported in *The Scrip* for February, they 'carry it under their arm.' The explanations of the oversensitivity of certain nerves of the eye to strong light, causing it to appear yellow; the dullness of certain nerves to weak light, making it bluish or purplish in tone; the principles of successive contrast, and more particularly of simultaneous contrast; the chapters on color constants, on the duration of the impression on the retina, on color mixture, on complementary colors, etc., etc., have been seized upon by these Frenchmen as the true explanations of many of the phenomena which for centuries have been puzzling painters. They look at the book as an endorsement of the new art and a blow at the old.

"That Professor Rood in his *Modern Chromatics* endorses impressionism is an assertion frequently enough made; but what he himself thought about the matter is not so generally known. I once had the opportunity of finding out. I had been abroad studying painting in the Paris art schools, and had also tasted impressionism in Giverny; my head was filled with violent violets and chrome yellows, and the forms of solid bodies seemed a la Giverny, as illusory as dreams. In this state of mind, with his book 'under my arm,' I went to call on my father to tell him that all the excellence of my pictures was due to his recipes. My enthusiasm was instantly cooled, however, when I saw him. He seemed ill and mentally much depressed.

" 'Are you ill?' I asked.

" 'No,' he replied; 'I am very well, but I have just been to see an exhibition of paintings at the galleries of Durand Ruel,' and he groaned.

" 'What are they?'

*Professor Rood's Theories of Color and Impressionism, by Roland Rood, in *The Scrip*, Vol. I, p. 215, April, 1906.

" 'They are by a lot of Frenchmen who call themselves "impressionists;" some are by a fellow called Monet, others by a fellow called Pissarro, and a lot of others.'

" 'What do you think of them?' I ventured.

" 'Awful! Awful!' he gasped.

"Then I told him what these painters said of his theories. This was too much for his composure. He threw up his hands in horror and indignation, and cried:

" 'If that is all I have done for art, I wish I had never written that book!'

"Some years later I had the opportunity thoroughly to discuss the question with him. It was in the country, and together we tried many experiments in landscape painting, always referring to his book for the rules. At times he seemed doubtful if in fact he had not endorsed impressionism; he seemed to feel that possibly while searching for truth in one direction he had also uncovered it elsewhere. Turner he understood and considered logical. The conclusion, however, to which he finally came is summed up in the last statement he made to me regarding the matter:

" 'My son, I always knew that a painter could see anything he wanted to in nature, but I never before knew that he could see anything he chose in a book.' "

LATER PAPERS.

Three chief topics occupied Rood in the period between the publication of *Modern Chromatics* (1879) and his death, in 1902. These, taken in the order in which his papers dealing with them appeared, were: *The production and measurement of very high vacua* (1880-81); *The photometry of lights differing from each other so greatly in color as to be incapable of comparison by the ordinary methods* (1893-99); and *The measurement of the exceeding high electrical resistances of various dielectrics, such as glass, ebonite, quartz, and amber* (1900-02).

In the meantime the problems of color measurement continued to receive attention and in 1892 he published an important paper under the title *On a color system.* In this work, which involved the preparation of hundreds of carefully graded paper disks, the coefficients of reflection and brightness of which were determined, he started with a pair of disks of complementary colors, and by comparing these with other disks differing from them slightly in tint was able to build up a complete system of

numerically connected hues until step by step the whole range of colors was included. In the following year he made a valuable contribution to the vexed question of the nature of the X-rays, in which he based his conclusion, that they consist of ether vibrations of short wave-length, upon a series of experiments on the reflection of such waves from a surface of platinum.

The study of high vacua was undoubtedly suggested by the work of Crookes, whose ingenious demonstrations of the varied phenomena of the electric discharge of rarefied gases and whose speculations as to their nature were attracting universal attention. In 1876 Rood published a paper describing experiments upon the Crookes radiometer which confirmed, to his own satisfaction at least, Stoney's theory of the action of that instrument.

Three years later Crookes, with a wealth of ingenious and brilliant experiments on *radiant matter,* revived and greatly extended the almost forgotten work of Hittorf. The phenomena offered a most attractive and promising field for further research, and indeed, as we now know, were the starting point for the most striking and important developments in the history of modern physics. It is noteworthy and characteristic that Rood selected as a subject for study, instead of the phenomena of the electric discharge, the question of the highest possible vacuum, and that by simple but effective modifications of the Sprengel pump he was able to carry the rarefaction of tubes to an unattained point.

Where Crookes had produced and measured vacua of 1/17,000,000 of an atmosphere, Rood reached 1/390,000,000, and did not consider even then that he had reached the utmost limit of experimental possibilities.

Subsequent investigations, it is true, led physicists to doubt the reliability of the indications of the McLeod gauge, which he used in his determinations, and for a time all measurements of very high vacua were questioned, but it is now conceded that with proper precautions approximately correct results are attainable.

By his discovery, which was announced in the first of his three papers dealing with flicker photometry, Rood contributed an entirely novel and very important principle to the science of physiological optics and placed in the hands of the student of illumination a valuable tool. That lights so differing in compo-

sition as to produce unlike color impressions upon the retina are incapable of direct photometric comparison had been universally recognized since the enunciation of the scientific basis of the art of photometry by Helmholtz.

Many indirect devices and methods had been proposed to avoid this difficulty and Rood himself had long had the problem in mind. Indeed, he published a paper in 1878 showing that, while a direct balance of values was impossible, one could obtain a fairly reliable estimate of the relative brightness of two surfaces differing in color by making the one certainly brighter and then certainly darker and striking an average. In his return to the attack in 1893 he showed, however, that by taking advantage of a property of the retina entirely unknown to physiologists and physicists the difficulty of comparing unlike illuminations vanished altogether.

When we gaze at a surface that fluctuates not too rapidly in brightness, there is a sense of flickering, and the same is true when two surfaces differing in brightness are alternately presented to our field of view. If now the illumination of the two surfaces be gradually equalized, the flickering will diminish and will disappear at equality. This is obvious when we have similar surfaces as to color illuminated by the same quality of light and it forms a criterion quite independent of brightness that may be used in photometry. Rood showed that the disappearance of flicker occurs in the case of two surfaces unlike in color or illuminated by light differing altogether in composition, and that in these cases also its disappearance was a reliable criterion of equality of brightness. Thus a new and invaluable method in photometry, that has since been extensively employed, was established. The principle of flicker photometry was soon after searchingly and exhaustively tested and verified by Whitman,* whose results have since been abundantly confirmed by many others, and what might well be designated as the *Rood effect* is an accepted fact in physiological optics and an inestimable boon to experimental psychologists, students of color, and photometricians.

The remaining three years of Rood's life were given to investigations in quite a different field. The problem which engaged

*Whitman, F. P.; Physical Review, Vol. III, 1896.

him was that of the measurement of exceedingly high electrical resistances, and with his usual fertility he devised a method which immensely extended the possible range of such determinations. The limit of even approximate estimates had been about 50,000 megohms. Rood's measurements of certain dielectrics ran to 2,000,000,000 megohms.

In this, his last research, a quality reappears which is typical of his genius. To many investigators a method is of interest only as a means to some definite result which they wish to attain. Others there are, and Rood was of this class, to whom a beautiful and ingenious method is in itself worth while. They spend themselves for it at no matter what cost of time and labor, even if they have no immediate and definite use for it. Rood had a passion for the development of delicate experimental methods. He delighted in the *tour de force* required to push the sensibility of an apparatus to its limit or in the invention of some novel device for determining the hitherto unmeasurable. At one time he devised a means for determining details which the microscope failed to reveal; at another he modified and defined Bunsen's photometric device so as to greatly enhance its sensitiveness. Where Wheatstone measured intervals of time not greater than a millionth of a second, he carried the determination down to times as much smaller relatively as a quarter of a minute is smaller than an hour. With his horizontal pendulum he could measure mechanically distances equivalent to ten Angström units, or a five hundredth of a wave-length of green light. His modification of the Sprengel pump further reduced the gas in the ordinary Crookes vacuum as a common air pump with valves would take out the air from a receiver at atmospheric pressure and to about the same extent. Finally, in the last of the three papers on high resistances, published but a few months before his death, he describes measurements, by a unique method of his own, of resistances so great that it is difficult to find a concrete expression for them. In the finest copper wire (No. 40) such a resistance would have a length sufficient to make a coil of one thousand turns with a diameter equal to that of the orbit of the earth. These things and others like them he did for the joy of doing them; and it is supreme achievement attained in this spirit that marks one of the highest types of the man of science.

Rood died on the twelfth of November, 1902, after having served on the faculty of Columbia University for thirty-eight years. During this long period he had the satisfaction of seeing his department grow from the meager beginnings in which he found it to an institution of the first rank, handsomely housed, richly endowed, and adequately equipped.

In his early days the emptiness of his environment at Troy did not prevent him from becoming an investigator. Later the far more dangerous environment of New York failed to corrupt him. In it he lived his own life, untouched by the commercial spirit that has wrecked so many promising careers in science, and died as he had lived, devoted to science and to art, a lover of the country and of children, a loyal friend, a simple-hearted man of genius.

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